THE UNIVERSITY of York

Teaching approach and success in A-level Biology

Comparing student attainment in context-based, concept-based and mixed approaches to teaching A-level Biology

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January 2013

Nuffield Foundation

This report should be cited as: Braund, M., Bennett, J., Hampden-Thompson, G., & Main, G. (2013). *Teaching approach and success in A-level Biology: Comparing student attainment in context-based, concept-based and mixed approaches to teaching A-level Biology*. Report to the Nuffield Foundation. York: Department of Education, University of York.

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Acknowledgements

This research project was funded by a grant from the Nuffield Foundation, an endowed charitable trust that aims to improve social well-being in the widest sense. It funds research and innovation in education and social policy and also works to build capacity in education, science and social science research. The Nuffield Foundation has funded the project reported, but the views expressed are those of the authors and not necessarily those of the Foundation. More information is available at www.nuffieldfoundation.org

A number of people at Edexcel-Pearson helped provide data and other support for the project:

Jeremy Pritchard
Peter Canning
Damian Riddle
Elena Softley

The project Advisory Panel reviewed progress of the project and made suggestions based on initial findings. In addition to the people from Edexcel-Pearson named above, the team would like to thank **Jeremy Airey** at the National Science Learning Centre and **Roger Lock** who served on this advisory panel and showed enthusiasm for and interest in the project.

The team are grateful for the time and effort given freely by the many biology teachers who returned questionnaires and talked extensively with researchers about biology teaching in their institutions.

Thanks are also due to **Yvonne Mason**, the administrator for the project, who tirelessly and efficiently dealt with communications and administrative matters and helped in production of this report.

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1.3. Analysis of examination results in 2009 showed students following the Edexcel context-based /SNAB course in A-level Biology obtained fewer higher grades nationally than students following more traditional, content-focussed courses.

2. Literature

2.1. Context-based approaches to learning biology and science provide an improved rationale for learning, better integration of concepts, improved student motivation and more examples of modern everyday applications of science.

2.2. Teaching biology/science in context involves teachers stepping beyond traditional repertoires to employ a wide range of teaching including more collaborative, student-centred learning.

2.3. Biology teaching at advanced level has been criticised for lacking variety in practical lab work, not providing enough opportunities for field study, ineffective use of ICT and for lagging behind developments in research in the subject and in teaching.

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2.7. There is evidence that context-based teaching improves students' ability to reason about biology content and ethical and moral standpoints and think more critically, though some biology teachers have been reluctant or slow to adopt group work strategies that make these outcomes more likely.

3. Methodology

3.1. A mixed-method approach was used involving quantitative analysis of examination and some survey data and qualitative analysis of questionnaire returns and interviews with Heads of Biology.

3.2. Teaching approaches; context, content or mixed, were identified for 344 schools and colleges using the Edexcel examination in 2010. Questionnaires were issued to all schools. A-level Biology teachers in 16 of the 106 schools returning questionnaires were interviewed.

4. Findings from quantitative analysis of examination results

4.1. There was no significant difference in the performance of students in A-level Biology between those following context-based/SNAB or content-based teaching approaches. Both sets of students achieved similar proportions of high grades (A*-C).

4.2. There was an apparently significant advantage in A-level performance for students following a mixed teaching approach over both context-SNAB and content-based approaches.

4.3. A higher proportion (about half) of selective-independent schools followed a mixed teaching approach compared with the other two approaches (context-SNAB or content-based).

4.4. When school type (selective/independent or non-selective/comprehensive) was controlled for, the apparent effect of a mixed teaching approach disappeared.

4.5. When previous performance at GCSE was controlled for, the apparent difference in favour of a mixed approach was minimal. GCSE scores and school type explained most of the variation in performance in A-level Biology.

4.6. Students from all five ability bands (based on previous performance at GCSE) performed similarly for all three teaching approaches with slightly more students from the highest ability band following a context-based (SNAB) approach obtaining high grades.

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5. *Findings from qualitative analysis of questionnaire returns and interviews with teachers*

5.1. The majority of teachers responding to the questionnaire across all three teaching approaches rated previous attainment, teacher experience, and school assessment and monitoring as important factors contributing to student success in A-level Biology.

5.2. About half of teachers responding to the questionnaire claimed they used a mixture of textbooks and other sources, though mixed approach schools were most likely to frequently use both content and context-focussed resources.

5.3. Teaching teams for A-level Biology are experienced in most schools. Teams in mixed approach schools had the most experience but there was little difference between teams in selective and non-selective schools.

5.4. In mixed approach schools it was often first contact with the context-SNAB approach via training/CPD that initiated mixing approaches and resources. Contact with the context-SNAB approach may have provided opportunities for teachers to expand their teaching repertoires.

5.5. Teachers' perceived advantages for a mixed approach included greater student autonomy and independent learning, promoting a way of learning that might be beneficial in higher education.

5.6. Teachers in schools using all three approaches often targeted either a context or content approach depending on the topic being taught.

5.7. Teachers in some schools used a mixture of textbooks to act as a 'safety net' ensuring all content likely to be met in examinations would have been covered.

5.8. There was a range of adherence to the storyline approach in contextualising biology. Some schools used a context-SNAB approach, using storylines, more in the first (AS) year of A-level teaching, using it less as final examinations approached.

5.9. In most schools where teachers were interviewed there was a growing use of ICT resources mainly to provide better access for students to learning materials. Context-based/SNAB schools were noticeably enthusiastic about the quality of ICT resources and the opportunities for learning afforded.

5.10. Most schools surveyed said they used out-of-school learning opportunities and in about half of schools use extended beyond 'field work'. Examples included use of facilities at local universities and research facilities helping demonstrate modern applications of bioscience and opportunities for careers.

5.11. In questionnaire returns the contribution of professional development (PD) to student success at A-level was often rated lower than other aspects, such as resource use, practice at

examinations and school visits. In the interviews most schools said they found training provided by the examination board helpful.

6. Conclusions

6.1. It is likely that a mixed approach is part of the advantages already attributable to selective and independent schools. These could include greater purchasing power for textbooks by parents and the school and the ability to draw on a wider range of in-school and out-of-school facilities for teaching and professional development.

6.2. Teachers' choices of approach are determined by the interaction of three clusters of factors. These clusters are concerned with: *external factors*, *student factors* and *teacher factors*.

6.3. External factors impacting teaching approach include the socio-economic background to the school that can be manifest, for example, in parental support and financial advantages for student learning and the interpersonal cohesion and effectiveness of teams of teachers. In the independent and selective state schools external factors are likely to have a pronounced positive effect, conferring additional advantage in terms of likely student attainment. This is not to say teachers choosing to adopt and use a mixture of teaching approaches and resources, in spite of the school in which they teach, does not have some advantage for students.

6.4. Student factors influencing teaching and student performance included previous attainment and interest in science/biology and their motivation to learn biology and enter a career in biosciences.

6.5. The extent of teachers' beliefs in and commitment to a context-based storyline approach to A-level Biology and their willingness to innovate and adopt more student centred interactive approaches to learning are important factors determining what teaching approach is adopted.

6.6. Teachers' views of the interrelationship or topic dependence (hegemony) of concepts in biology probably affect the extent to which they are prepared to use a context-based approach and adopt its associated pedagogy.

6.7. A factor the study could not evidence but that is likely to be important, is the extent of the cohesiveness of teaching teams and their ability to act as professional communities sharing and reflecting on the suitability and efficacy of teaching approaches and resources.

6.8. Having one specification for Biology, that could be taught by one or the other or a mixture of teaching approaches, has opened up a professional space for teachers' decision making. Teachers that might not otherwise have seen the benefits of teaching using the types of student-centred, interactive activities that SNAB has invested in and developed, have been exposed to new ideas.

7 Recommendations

7.1 Recommendations for schools

- Constructing teaching teams, where there is a balance between teachers with some years of experience at teaching biology at A-level and new teachers, helps create a collaborative environment in which a mixture of different resources and teaching approaches can be critically reviewed and selected for their benefits to student learning.

- Drawing on both concept and context-based approaches, and critically evaluating resources within a collaborative and creative professional environment, may positively impact students' performance in A-level biology.

- A 'storyline' approach to teaching biology, where concepts are met through meaningful and contemporary settings, helps students appreciate the interconnectivity of biological ideas and processes and provides sound motivation and engagement for learning at advanced level.

- Using a wide range of out-of-school sources for learning helps students attach meaning to taught biology, to see applications of modern biology, have knowledge of cutting edge advances in the subject and to develop positive orientations towards future careers in biological sciences.

7.2 Recommendations for the Edexcel Examination Board

- Providing a common specification and examination for Advanced Level biology allowed some teachers to meet a range of approaches and resources that might not otherwise have seemed appropriate to support student learning. This supports a mixed approach to biology teaching at this level which is an advantage to students in some schools.

- The promotion and supply of a diverse set of high quality resources including textbooks, revision materials and ICT and online materials supports a diversity of approach which has advantages for student learning.

- Continuing to provide units of the examination that have some degree of teacher input, current units 3 and 6, allows teachers to enjoy some flexibility in their planning and teaching and to draw on a wide range of expertise and out-of-school situations to students' advantage.

- Providing support for teachers' professional development in teaching and assessing biology at advanced level remains an important role of the examination board. Promotion of diversity in teaching approach including the use of student-centred and interactive teaching methods should be part of future programmes.

7.3 Recommendations for teachers' professional development

- Professional development (PD) is important to teachers at advanced level who sometimes feel left out as they see more effort made for teachers of students at earlier stages (KS3 and KS4).

- PD for biology teachers at advanced level should expose participants to as wide a range of teaching methods as is possible. Resources to teach content, both concept-led and context-based, should be experienced by PD participants so that they can judge the advantages of teaching using both approaches.

- Teachers on PD courses in A-level biology teaching should be helped to see ways that concepts and processes in biology interrelate and can be part of more than one topic content area.

- Participants in PD courses should be exposed to case studies of practice of a wide range of examples of out-of-school sources for teaching biology to show how students have attached meaning to taught biology, have seen applications of modern biology, have gained knowledge of cutting edge advances in the subject and have developed positive orientations towards future careers in biological sciences.

1. Introduction and background

1.1. Introduction and structure of the report

This report is of a study to explore A-level Biology results in relation to teaching approach. The research was supported by a grant from the Nuffield Foundation (ref: EDU/40049). The project was conducted by the Centre for Innovation and Research in Science Education (CIRSE) of the Department of Education at the University of York and began in June 2011. The research was completed at the end of July 2012. This introductory section includes a rationale for the study, questions guiding the research and some background to teaching approaches including Salters-Nuffield Advanced Biology (SNAB).

Following sections provide a comprehensive review of the literature on context-based (Science Technology and Society - STS) approaches to teaching, a description of the quantitative and qualitative methods used in the study, the findings, and a conclusion which includes recommendations for further consideration.

1.2. Rationale for the study

The study developed from concerns about comparisons of outcomes of context-based courses with those from more traditional concept-based courses. The first concern derived from critique of previous studies on the impacts of context-based approaches to teaching science and a second from concern that fewer top grades were being achieved by the context-led (Salters Nuffield Advanced Biology) SNAB cohort compared to other specifications.

Evidence from a systematic review of international research on the effects of context-based teaching concluded that such approaches appear to motivate pupils in lessons (Bennett, Hogarth and Lubben, 2003). While Bennett *et al*. found some evidence to support the claim that context-based approaches do not adversely affect pupils' understanding of scientific ideas; the reliability of studies in this area has been challenged. Criticisms centre mainly on methods used to measure conceptual change for two different sets of student experiences. For example, some studies have used different test-exam items or have too close a match between criteria for course design or content and those for assessment (Barab and Plucker, 2002; Bennett, Lubben and Hogarth, 2007). One problem has been that in some studies students following context-based approaches have (quite naturally and unproblematically in the eyes of researchers) been tested using questions that value and draw on the approach they have been taught, while those following more conventional courses have been tested using questions more aligned with the other (conceptual) approach. A resulting outcome is that context-taught students naturally do well on context-type questions and concept-taught students do well on concept-led questions.

Comparing the performance of students in the SNAB (context-led) examinations with results for students completing Edexcel's non-context Biology examinations in 2009, prior to the new common specification examined in 2010, showed that students following the context-led course did less well in terms of higher grades attained (**Table 1.1**). These differences could have been due to the different content of the two separate specifications, the style of the different examinations, the

differences in style of coursework used in the two courses and/or variation in the quality and accessibility of the student resources. Performance differences might also have been linked to difference in previous attainment of students entering these courses. For example in the 2009 examination, the traditional concept-led Edexcel cohort had a higher percentage of students achieving GCSE A* and A grades (56% compared with 46%) so one might naturally have expected these students to have achieved more A or B grades at A-level.

It has never been possible to say, with any degree of confidence, that any differences in results are associated with following a particular approach to studying Biology (concept or context or a mixture of the two).

In 2008 Edexcel produced a single Biology A-level specification with the same content presented through both context and concept approaches. It should be emphasised that the context-approach within the Edexcel specification was developed by the SNAB team. Biological concepts were carefully threaded into the storylines (see Section 1.5 below) as they became relevant. The SNAB context-led specification statements were then reorganised into a concept-led approach by Edexcel, effectively clumping together statements about concepts which were dispersed in the SNAB context-led approach.

So, for the first time, a single specification and examination was available, providing schools with the option of teaching exactly the same content following either the context-led (SNAB) or concept-led (non-SNAB) routes, or using any mixture of approaches. A common set of examinations assessed the specification content learning outcomes for candidates following both routes and the same coursework was completed by all candidates. This made direct comparison of the effect of the different teaching approaches possible for the first time (for the first full examination in 2010) providing a unique opportunity to address the shortcomings of previous research studies.

Table 1.1 - 2009 results for the SNAB specification, Edexcel Biology specification (concept approach) and for all A-level biology specifications offered by the three awarding bodies, AQA, Edexcel and OCR (2007 and 2008 results showed a similar pattern).

	Entry (n)	Cumulative percentages for different grades				
		A	B	C	D	E
SNAB A2 cash-ins	4,067	20.7	44.8	67.7	84.6	95.3
Edexcel A2 cash-ins	6,990	28.7	50.7	71.2	86.4	95.5
All A level specifications	55,485	27.8	50.3	70.2	85.8	96.0

1.3. Research questions

Bearing in mind the considerations discussed above, the following research questions were set for the study:

Research question 1 (RQ1): Is there a difference in attainment in Edexcel examinations of Biology students who were taught using context (SNAB), concept (non-SNAB) or a mixture of approaches?

Research question 2 (RQ2): What are value added attainments at A2 level (i.e. taking account of GCSE average points scores at entry) of Biology students who were taught using different approaches?

Research question 3 (RQ3): What in-school factors help explain differences in student performance in A-level Biology, for example; student motivation and interest in Biology, teacher's experience and professional development, resource use (including books and ICT) and out-of-school work?

Supplementary question

Research question 4 (RQ4): Are 'stay on rates', from AS to A2, different for the three different teaching approaches?

1.4. Teaching approach

In this study 'teaching approach' refers to the main emphasis placed by a teacher in facilitating student learning of content. Thus in a 'concept-based' approach the content is taught using a traditional science framework with topics based around biology concepts, for example cell structure and function, biochemistry, enzymes, and photosynthesis.

In a context-based approach topics are based around a context (a storyline or contemporary issue), such as risk and cardiovascular disease, genetic disease or climate change, to make the relevance of learning obvious. Biological principles are introduced when required to aid understanding of the context. In a context-based approach concepts met in dedicated traditional biological topics are often split between contexts, they are revisited and extended in later topics building on previous learning.

In a mixed approach the teacher frequently draws (more or less equally) from these two approaches and typically addresses topic content using materials from both concept and context-focussed text books and other resources.

1.5. Salters Nuffield A-level Biology

Salters-Nuffield Advanced Biology (SNAB) was introduced as a nationally available advanced level course in 2005 following a full pilot study with 50 schools in 2002-2005. The course was developed in response to a previous dearth of curriculum development in Biological sciences curricula at the same time as rapid advances and expansion in the knowledge base in this area of science (see Reiss, 2005). Although Biology has often been perceived to have fewer problems than Physics or Chemistry in

motivating students and encouraging them into advanced study, teaching was criticised as dull, lacking in variety and with little opportunity for student involvement (Lock, 1998). Additionally, resources for teaching Biology at advanced level made little use of advances in ICTs.

Development of the course began in 2000 and involved the University of York Science Education Group (UYSEG) working in conjunction with the curriculum team at the Nuffield Foundation. The 'Salters approach', seen in other manifestations of science courses at A-level in Chemistry and Physics and in the GCSE course – 21st Century Science, is centred on teaching science through real-life contexts. For example, many A-level biology courses start with cell biology or biochemistry but in SNAB the opening topic concerns cases of a 15-year old and an adult with cardiovascular conditions. The biochemistry of fats and carbohydrates is introduced as a consequence of understanding their roles in cardiovascular disease rather than as content to be learned about the taxonomy and biochemical properties of groups of chemicals.

Similarly, transport across membranes is considered in the context of cystic fibrosis rather than through learning membrane form and function. Studying this disease also allows the introduction of genetics and so one context can be revisited in different content areas. Unlike more conventional courses, SNAB has reflected current epistemological consensus in the biological sciences community. For example, in genetics gene expression and polygenic inheritance are included, but not dihybrid inheritance. More detailed content, for example on immunology and PCR (Polymerase Chain Reaction – a technology used in DNA fingerprinting) is included so as to help understanding of core ideas and to avoid a tendency to rely on rote learning resulting in superficial understanding.

SNAB encourages a high level of student engagement and involvement and a wide variety of teaching styles, including; debate, argumentation and discussion, critical analysis of information, practical investigation, simulation and modelling of processes and phenomena, collaborative work and interaction with student-centred ICTs. SNAB introduced an innovative assessment scheme that included a critical report of a visit or topical issue related to modern applications of biology and this was incorporated into the assessment scheme for the common specification, first examined in 2010.

In 2008 the Edexcel examination board provided one examination specification for Advanced level Biology with a common unit structure, as explained on page 9. Later parts of the report refer to specific UNITS of the Edexcel specification. Table 1.2 below summarises the content, assessment types and mark weightings at AS and A2 for each unit. A fuller version describing the content and context related settings for each unit is provided as ANNEXE A.

Table 1.2. UNITS of the Edexcel A-level Biology specification examined in 2010

UNIT	Unit title	Type of assessment	% marks AS	% marks A2
1	Lifestyle, transport, genes, health	External written exam	40	20
2	Development, plants, environment	External written exam	40	20
3	Practical biology and research skills	Teacher assessed with externally marked option	20	10
4	Natural environment, species survival	External written exam	-	20
5	Energy, exercise, coordination	External written exam	-	20
6	Practical biology and investigative skills	Teacher assessed with externally marked option	-	10

2. Review of the literature

2.1. Scope of the review

The review of the literature is based on a systematic search of journals and databases and publications such as on websites, in policy and examination board documents, and from recent international conferences and seminars. The scope of the review is wider than sources only concerned with teaching biology in context as most research effort has been in other science disciplines, most notably in chemistry. Outcomes of most studies are considered relevant for all science subjects, including biology.

In the last decade there have been two large-scale systematic reviews of context-based science education. The first was carried out by researchers at York and was commissioned as part of a government sponsored initiative called the Evidence-Based Policy and Practice Initiative (EPPI) (Bennett, Hogarth and Lubben, 2003; Bennett, Lubben and Hogarth, 2007). This review had to use selection criteria set by the central review team and this limited selection of studies to large scale experimental designs using controlled (non-intervention) groups. The second review by Sadler (2009) covered a wider base of evidence of impact of context-based courses than the York study and was published in the review journal, *Studies in Science Education.* These publications formed a useful starting point for this review and a source of secondary studies to follow up.

Based on some knowledge in the field and the reviews mentioned above, seven journals were searched for relevant articles published between 1995 and 2011:

International Journal of Science Education
Science Education
Journal of Research in Science Teaching
Research in Science Education
Studies in Science Education
Journal of Biological Education
School Science Review

Two education databases, the British Education Index (BEI) and the Education Resource Information Centre (ERIC) were searched for relevant articles published in the same time frame as for the search of journals. Conference proceedings of the following prominent organisations in science education, published in the last ten years, were scrutinised by sight or searched by the selected keywords (see below), where this facility was available:

National Association for Research in Science Teaching (NARST)
European Science Education Research Association (ESERA)
International Organisation for Science and Technology Education (IOSTE)
South African Association for Research in Science, Mathematics and Technology Education (SAARMSTE)

Some sources, for example the MA thesis on SNAB by Jenkins (2007), were included on personal recommendations of team members or other professional contacts.

2.2. Search criteria – keywords

Sources, published in English between 1995 and 2011, were searched on the following keywords:

Context-based
Context-led
Impact
Science-Technology-Society (STS)
Authentic
Science
Biology

The keyword 'authentic' was included after reading the article by Shaffer and Resnick (1999) who identified four perspectives of authenticity; real-world authenticity, authentic assessment, personal authenticity, and disciplinary authenticity. It seemed the first and third of these perspectives might uncover relevant work but, as summarised by Yarden and Cavalho (2011), most studies are concerned with ways in which courses in schools try to model the activities and inquiries carried out by biologists-scientists so that they are a more realistic representation of 'real science'. Subsequently studies in the area of the 'authentic curriculum' were considered to be of peripheral interest as they deal with a more limited part of context-based teaching.

2.3. Structure of the review

The review is divided into sections covering: a rationale for context-based learning in science, definitions and examples of context-based learning, centres of activity in context-based approaches and evidence of impact of context-based science.

2.4. A rationale for context-based learning in science education

Several publications identify a main driver for development of context-based teaching in science as student disaffection and boredom with ways in which science is presented in traditional concept-led courses (Anderson, Holland and Palinscar, 1997; Bennett, Hogarth and Lubben, 2003, 2007; Cho, 2002; Gilbert, Bulte and Pilot, 2011; Hsu, van Eijck and Roth, 2010; Lock, 1998; Lubben, Bennett, Hogarth and Robinson, 2002; Parchmann *et al*., 2006; Parchmann and Luecken, 2010; Pilot and Bulte, 2006; Ramsden, 1997; Reiss, Millar and Osborne, 1999; Sadler, 2009). Though pupils' attitudes to school science seem far worse in physics and chemistry than in biology (Bennett, 2003; Osborne, Simon and Collins, 2003) this has not meant that efforts to contextualise biology teaching have been ignored and, of course, SNAB is an example of such actions.

Gilbert, Bulte and Pilot (2011, p. 890-891) list five problems in science education that can be addressed by following context-based approaches:

(1) Widespread curriculum overload with many isolated facts and concepts of varying significance included for students to be able to get a mental overview of the science or sciences being studied.

(2) The content of the curriculum is fragmented so that there is incoherence within and between the conceptualisations attained by students—a worthwhile 'mental map' is not achieved.

(3) Students often cannot transfer knowledge to situations other than the one in which it was learned.

(4) The knowledge taught is too often not relevant to students' everyday lives.

(5) Confusion about the reasons why science should be learned by students.

According to these authors, context-based courses avoid these problems by providing learning framed within a context which is expected to be relevant to the students. Students' involvement in the context(s) is expected to legitimise learning and attainment of formal science (p. 819). Duranti and Goodwin see context as a focal event for science learning having: a *setting,* temporal and spatial; a *behavioural environment* (of participants) that frame the discourse about and in it; a *language* through which participants communicate; broader *language of register* in science such that there is wider application to students' mental maps of knowledge. In other words there is prominent constructivist element in context-based courses (Duranti and Goodwin, 1992, p. 6-8).

Teaching science in a context requires departure from traditional teacher-driven learning to a style incorporating more learner-centred activity (Cho, 2002; Lubben, Bennett, Hogarth and Robinson, 2002). Parchmann and Luecken (2010) see this as challenging as, not only does teaching require a wider range of approaches, but also that content might be outside teachers' previous experiences in the subject domain. These demands prompted the progressive involvement of teachers arranged as regional school clusters in the design, research, implementation and professional learning that is the basis of the "*im-Kontext*" family of science courses in Germany (see later, section 2.7).

Even though biology seems to have enjoyed a more positive reaction from school students than in physics or chemistry, there have been criticisms that Biology has become less interesting in the last 20 years, due partly to a reduction in opportunities for practical work involving living things and field work (Lock, 1998; Tranter, 2004). Reasons for the decline in these opportunities are suggested as including: increasing costs, teachers' misconceptions of what is allowed under health and safety rules and over-reliance on video and other ICT resources, such as PowerPoint, as alternatives for contact with living specimens in the laboratory and field. Lock (1998) reported a consensus from biology teachers, educators, inspectors and others attending meetings who concurred that advanced level biology was too reliant on textbook-dominated, language-heavy teaching with scant references to modern biology and too few opportunities for biology teachers to pursue topics of their own and their students' interests. The literature originating from those who designed and/or researched SNAB shows how the course has addressed these issues (see for example, Dunkerton, 2007; Hall, Reiss, Rowell and Scott, 2003; Jenkins, 2007; Lewis, 2006; Lewis and Scott, 2006; Reiss, 2006; 2008). The use of contextualised 'science storylines' that address the most important issues and key ideas of science of interest to students and have longevity in terms of importance to society was suggested in the influential report, 'Beyond 2000: science education for the future', published by the Nuffield Foundation (Nuffield Foundation, 1998; Reiss, Millar and Osborne, 1999).

Writing on the key difference between SNAB and previous examination specifications at A-Level, Reiss commented that:

> *Specifications have traditionally been constructed from a scientist's viewpoint with the concepts being developed in a way that is seen to be sensible by a scientist. Typically this means that pre-eminence is given to scientific concepts (Hart, 2002). But many students see things differently and want teachers to show them why the concepts are important. One possibility is to make the context—or storyline—the driving force.*
>
> Reiss, 2008, p.891.

2.5. Definitions and examples of context-based learning in science

In the York EPPI review, the research team used the following definition for context-based approaches:

> *Context-based approaches are approaches adopted in science teaching where contexts and applications of science are used as the starting point for the development of scientific ideas. This contrasts with more traditional approaches that cover scientific ideas first, before looking at applications.*
>
> (Bennett, Lubben and Hogarth, 2006. p.7)

In the US and some other countries the term Science-Technology-Society is broadly synonymous with a context-based approach and so the definition provided by Aikenhead (1996) is helpful:

> *STS approaches [are] those that emphasise links between science, technology and society by means of emphasising one or more of the following: a technological artefact, process or expertise; the interactions between technology and society; a societal issue related to science or technology; social science content that sheds light on a societal issue related to science and technology; a philosophical, historical, or social issue within the scientific or technological community.*
>
> (Aikenhead, 1994, p.52-53)

Examples of context-based approaches in science range in the type and duration of intervention, from individual enrichment tasks used in lessons through whole lessons or sequences of lessons to whole courses of a term or more. In the majority of cases, for this review, the studies are of whole courses of a year or more unless stated.

Gilbert (2006) identified four models for the design of context-based courses:

(1) context as the direct application of concepts;
(2) context as reciprocity between concepts and applications;
(3) context as provided by personal mental activity;
(4) context as the social circumstances.

In model 2, which applies to most context-based courses researched and reported in this review, Gilbert, Bulte and Pilot (2011) describe this model as providing;

> "*a situation … selected (by the teacher or course designer) as a vehicle through which key concepts can be taught. The assumption is that there is a cyclical relation between concepts and context throughout the teaching, that is after the concepts are taught, their application in the context is presented, and then a new aspect of the context is focused upon as a prelude to the teaching of new concepts*"
>
> (Gilbert, Pilot and Bulte, 2011, p. 823).

These authors clearly favour models 3 and 4 claiming that in models 1 and 2 contexts are merely 'decorative'. They see models 3 and 4 providing better examples of courses where contexts are deeply embedded in teaching and lead to more reflective learning within the context itself. However, the examples they review are in FE or job-training situations where models 3 and 4 are a more natural consequence of career-oriented learning, rather than in the broader based learning environments found in school science. It should be noted that SNAB is a variant of Gilbert's model two where contexts are certainly not 'decorative'. In SNAB multiple biological topics are intellectually threaded to provide essential storylines so as to access concepts rather than being chosen for suitability to fit a certain context after the concepts have been taught.

2.6. Centres of activity in development and research of context-based learning in science

The York EPPI review, in 2003, identified four main loci of effort in context-based approaches leading to design, implementation and evaluation of whole courses:

(1) In the US, *Chemo* (American Chemical Society [ACS], 1988) and the Iowa project, Scope, Sequence and Continuity (Yager and Weld, 1999).

(2) In the Netherlands, PLON: (The Physics Curriculum Development Project, 1988).

(3) In the UK, The Salters' suite of courses.

(4) In Israel, *STEMS* (Science, Technology Environment in Modern Society) (Tal *et al.,* 2001).

Since this review there have been important additions, particularly relevant to Biology: the *im-Kontext* (in–context) suite of courses, coordinated through the Leibnitz-Institute for Science Education (IPN) at the University of Kiel (see below) and *BIOMIND,* an intervention project in inquiry-based authentic learning in Israel.

The "im-Kontext" family

In response to criticisms of science in the German education system and following unfavourable results of TIMSS and PISA, the Leibnitz-Institute for Science Education (IPN) at the University of Kiel, in conjunction with various other universities in Germany, set up (from 2002 onwards) context-based courses for schools in each of the science disciplines, "*Biologie im Kontext*" (BiK), "*Chemie im Kontext*" (ChiK) and "*Physik im Kontext*" (PiKo). All three schemes are based on the idea of 'symbiotic implementation' (Eilks, Parchmann, Gräsel, and Ralle, 2004; Gräsel and Parchmann, 2004; Pilling,

Holman, and Waddington, 2001) whereby courses are co-developed and researched from the start by teachers in regionally based clusters of schools working in conjunction with academics and teacher educators in education departments or pedagogical institutes of partner universities. *ChiK* was the first to be established (in 2002), funded by the German Federal Ministry of Education (BMBF) and participating states. The central goal of this project was to implement the ideas of context-based learning (e.g. along the lines of Salters Chemistry) into the school systems of the federal states and to gain further insight into conditions fostering and hindering implementation of school innovation (Parchmann *et al*., 2006, p.1043).

As with all *im-Kontext* courses, *Biologie im-Kontext* is aligned with four areas of competency identified in Germany's national standards: subject knowledge, inquiry acquisition, subject-related communication and valuing and decision-making. PISA has had an influence on course design, as areas identified by the PISA team have been used as foundations for course content: life and health, Earth and environment, technology and genesis of knowledge (Prenzel *et al.*, 2004). Unlike SNAB, the teaching appears to use the context-topic as a vehicle for skills acquisition rather than to thread together a coherent set of biological concepts. As most *im–Kontext* group cluster projects included schools of so many different types and classes of widely varying ability and ages, research on impacts on student learning outcomes and attainment is very limited. The majority of research effort has been on the match of course design with theoretical models of aims and purposes of the science curriculum (Hamman, 2011) or on the operation of learning communities and impacts on professional learning of teachers (see: Elster, 2010a; 2010b).

BIOMIND

BIOMIND is a 12-month intervention comprising about 20% of a biology course for 16-18 year olds in Israel (Zion *et al*., 2004). It is based on the claim that, to be authentic, inquiry-based learning (IBL) ought to be as close as possible to the styles and processes of IBL as used by practising scientists. *Biomind* has an assessed component that allows for autonomous but supported IBL study (involving tutor feedback) of whole organism biology in the field and laboratory. The aim is to help students think like biologists where all the elements of research are included such as; searching for and reading relevant articles, planning, observation and initial experimentation, hypothesising, focussed experimentation/hypothesis testing and preparation of research reports. Research outcomes are limited to evaluation of course provision against aims and some non-quantitative evidence that students have improved 'concepts of evidence' as a result of following the course (Zion *et al*., 2004).

2.7. Evidence of impact of context-based approaches in science education

The majority of research studies have concentrated on the effects (impacts) of context-based learning approaches on students' attitudes (to science subjects and/or to studying science subjects in schools), students' abilities, skills or knowledge in the subject or more general educational outcomes such as critical thinking, argumentation or decision-taking. There have been a few studies of gains in professional learning of teachers or of change in teacher behaviours, task selection or variety in teaching, as a result of moving to using more context-based approaches.

2.7.1. Evidence of impact on students' concept learning

The majority of studies seem to show that concept learning outcomes from context-based courses are at least as good as from 'traditional' (concept-led) courses (Bennett, Lubben and Hogarth, 2007). There are a few examples of studies that show a marked impact in favour of context-based studies. In research associated with a science project in Iowa, students taking a context-based course showed significantly better understanding than those following traditional courses (effect size 1.52). Improvements were most notable for lower ability pupils and female students (Yager and Weld, 1999). In a rare RCT study by Tsai *et al.* (2000), students following an STS course showed less frequent misconceptions of key science ideas than those who had not experienced the course. In a more recent study in Colombia, Castano (2008) compared discussion outcomes of two groups of 4th graders (9-10 years old), one who had discussed STS issues and one that had not. Improved definitions for concepts in biology were noted for the STS group including of; ecosystem, biotic-physical interrelationships, food chains and impacts of alien species. In the *Biomind* project in Israel, Zion *et al.* (2009) claim that students following the course had improved concepts of evidence, though their evidence base for these claims is rather questionable. In another Israeli study, Dori, Tal and Tsaushu (2003) showed a very large effect (effect size 2.27) for gains in knowledge of concepts in biotechnology. In this study it was the very large gains for lowest ability groups that resulted in this effect size. The highest ability groups showed little or no shifts in their already satisfactory, understanding.

There are studies showing an improved understanding of concepts closely associated with the teaching context of an STS intervention. For example Klosterman and Sadler (2010) showed students following an STS approach had improved concepts of global warming. A study by Khishfe and Lederman (2006) showed slightly less significant gains in the understanding of the same concepts (associated with global warming and climate change) but that students showed a much finer grained appreciation of the nature of science. Zohar and Nemet (2002) showed that STS enrichment lessons on genetic diseases and genetic counselling improved knowledge of basic genetic processes. However, gains in appreciation, knowledge and understanding of the nature of science, according to Sadler's review (Sadler, 2009, p. 25), remain elusive with little empirical evidence to support positive changes due to teaching in STS contexts.

Critiques of studies of impact on students' concept learning

There have been criticisms of research on the impact of context-based STS approaches on students' conceptual understanding. These centre mainly on the reliability of methods used to measure conceptual change for two different sets of experiences (e.g. through using different test-exam items) or on the too close match between criteria for course design or content and those for assessment (Barab and Plucker, 2002; Bennett, Lubben and Hogarth, 2007). The main problem has often been that students following concept-based approaches have (quite naturally and unproblematically in the eyes of some researchers) been tested using questions that value and draw on the approach they have been taught through while those following more conventional courses have been tested using questions more aligned with the other (conceptual) approach. The obvious outcome is that context-taught students do well on context-type questions and concept-taught students do well on concept-led questions.

In a study by Winther and Volk (2004) the researchers claim that the differences in assessed outcomes in favour of students taught using STS approaches was underestimated because they were tested using conventional methods that favoured conceptual learning over contextualised learning. In this case the researchers seem to favour a methodological bias that could improve the size of the slight effect they reported! In the case of the Yager and Weld (Iowa) study, reported earlier, test items were designed by the researchers who were also engaged in course design and development. Thus course objectives that underpinned the teaching were aligned with the test items used to measure the effect of the course. This closeness between design and evaluation led Bennett, Lubben and Hogarth to wonder if, in the future, evaluation ought to be separated from course design and carried out independently by those who were not commissioned in course design and development (Bennett, Lubben and Hogarth, p. 367). However, it is worth pointing out that, where evaluators were also course designers, no actual evidence of bias was found in studies considered by the York EPPI review teams.

In an early study of a Salters Chemistry course at GCSE level, Ramsden (1997) avoided bias in test design by selecting uniquely designed question items and adapting others from a bank of test items, independent from the taught course. Barab and Plucker (2002) used questions randomly selected from TIMMS and NAEP to avoid similar methodological criticisms. It is interesting to note that in both these studies (Barab and Plucker, 2002; Ramsden, 1997) no significant performance differences were noted between treatment and control groups. In Swaziland researchers explored student performances of groups following context and non-context teaching using both treatment related test items and the reversed styles of tests for each treatment group and found no significant differences in performance (Dlamini, 2003; Putsoa *et al*, 2003).

These latter studies are almost unique as few researchers seem to have used an equivalent testing situation to measure differences in concept knowledge and understanding that might be due to differences in teaching approaches. This is one of the reasons why this current study of teaching approaches and students' assessed outcomes (using examination results), is important as it avoids the problems noted above by drawing on results from a common examination where all questions are taken by candidates irrespective of which teaching approach was followed.

2.7.2. Evidence of impact on students' attitudes, motivation and interest in science subjects and to science subject teaching

There is much stronger evidence of positive impact of context-based teaching of science on students' attitudes, interest and motivation than there is of shifts in student performance (Bennett, Hogarth and Lubben, 2003; Bennett, Lubben and Hogarth, 2007; Ottander and Eckborg, 2011; Parchmann and Luecken, 2010; Sadler. 2009). For example, in the York EPPI review only four of the 17 selected experimental studies of performance change showed definite improvement in conceptual understanding for students following context-based courses, while seven of the nine studies that explored students' attitudes showed positive impacts. Of these studies two, in particular (Smith and Mathews, 2000; Yager and Weld, 1999), show that girls in classes following STS approaches held more positive attitudes to studying science than their female peers in classes taught using conventional (concept-led) approaches.

Part of a rationale for teaching science in context (discussed in section one) is that courses provide increased motivation for students to continue to study a science subject at a higher level or to enter a science-based career, because they have been (more) interested in the subject at school or college. Evidence from evaluation of *ChiK* in Germany indicates that this was true for students in many of the schools involved in the project (Parchmann, *et al*., 2006) as was the case in research on Salters chemistry courses (Barber, 2000; Ramsden, 1997).

Smaller scale interventions and enrichment actions of an SSI (Social-Scientific Issues) nature can improve student motivation and interest. For example, Albe (2008) analysed student discussions in lessons about risks of mobile phone use and claimed they improved motivation. Bulte, Westbroek, de Jong and Pilot (2006) showed that student motivation improved as lesson designs shifted from a content only focus towards lessons focussed more on contexts of local interest, such as about water supply quality.

In a few studies there is evidence that students' improved attitudes or motivation might be more to do with a change in school routines than in the ways in which science content was taught. For example in a study by Harris and Ratcliffe (2005) of a 'collapsed day' arrangement in the UK, where the normal subject allocated timetable is suspended to allow for day-long studies integrating science with humanities subjects, the researchers found it difficult to distinguish between effects due to changes in teaching contexts from changes in the school timetable. Sadler (2009) comments that students in some *ChiK* project schools saw context-based lessons as just another science learning experience, different in that contexts featured more prominently, but generally consistent with the type of teaching previously experienced. Sadler comments that this contrasted with somewhat exaggerated positive expectations of teachers' views of how they thought pupils had perceived the course. In Jenkins' study of student attitudes to plant biology in SNAB and non-SNAB classes ,it was found that SNAB made little difference but that students' realisation of the importance of studying plants had improved slightly for the SNAB group (Jenkins, 2007).

2.7.3. Evidence of impact on students' critical thinking and argumentation

Commensurate with a marked increase in research activity on argumentation and critical thinking in science education in the last ten years (see for example, Jimenez-Aleixandre and Erduran, 2008), there have been a number of studies that have explored whether teaching in context using STS approaches improves these qualities. Early studies exploring links between thinking analytically and experiencing lessons set in everyday contexts showed such links are supported (Gil-Perez, 1996; Perrone, 1998). More recently, Zeidler et al. (2009) studied four classes of 16-18 year old students enrolled in anatomy and physiology classes in treatment and control groups and found a significant increase in examples of reflective reasoning (measured on the RJM scale) for the treatment classes (effect size 0.76). These researchers concluded that familiarity and personal connectedness with the teaching contexts produced higher level argumentation and reasoning and a more sophisticated epistemological understanding.

In Zohar and Nemet's study of SSI treatments in teaching genetics (Zohar and Nemet, 2002), researchers found that, although students in treatment groups showed an overall decrease in the numbers of conclusions stated, the mean number of justifications per conclusion and the numbers of ideas expressed in conversational turns increased significantly. Zohar and Nemet also showed that

students showed an increase in the amount of biology content they brought into their arguments. Similar increases in justifications made and in the quality of argumentation have been noted for students engaged in STS activity (Albe, 2008; Tal and Kedmi, 2006).

Reiss analysed students' ethical reasoning in visit/issue reports submitted for the SNAB examinations on the basis of frameworks identified in teacher guidance: rights and duties, utilitarianism, autonomy and virtue ethics (Reiss, 2008). His study found that utilitarian ethical reasoning was often based on examples of consequential reasoning and was widely used. The remaining frameworks were used substantially less often. In addition he found that students mostly argued anthropocentrically though many of them also argued ecocentrically and/or biocentrically.

2.7.4. Evidence of impact on teaching

The main thrust of research on the *im-Kontext* suite of courses has been to explore shifts in teachers' perceptions of changes in their teaching, particularly towards more competence-based and student-oriented approaches that might be due to teaching science subjects in context (Elster, 2010a; 2010b; Parchmann and Luecken, 2010). As far as teachers' intentions to change are concerned, five criteria seem to have emerged that are most significant as predictors of change: collaboration, having a common goal, output orientation, reflection and continuous teacher learning (Parchmann and Luecken, 2010). In the physics course, *PiKo*, teaching changes away from traditional methods seemed to be linked with the extent to which teachers could see the benefits of students' more independent learning. In the *ChiK* projects, most change in teaching was in schools where school visits were part of the associated INSET (Parchmann and Luecken, 2010).

In her evaluation study of the SNAB pilot, Lewis used interview data to look at teachers' treatment of biological content, use of discussion, encouragement of 'active learning', approach to practical work, use of computer-based resources and selection of activities (Lewis, 2006; Lewis and Scott, 2006). She found that, at first, some teachers brought in more content than was required, for example about stages of meiosis in the topic on inherited diseases such as cystic fibrosis, when this was clearly not required. Reasons were to do with teachers' traditional established repertoires, wanting to give a more complete 'picture' of the biology or including what were thought to be better or additionally interesting examples of the biology. Where teachers used discussion, it was about established knowledge rather than contested knowledge or ethical or social issues in biology. Where these second two types occurred, discussions proved problematic because whole class discussions lacked focus or teachers felt unpractised in the pedagogical approaches required to run productive discussions.

Lewis also found teachers had varied views on what constitutes active independent learning and how to facilitate or manage it. One or two felt uncomfortable with this aspect. Teachers' abilities to adopt more open-ended investigative practical work depended on the extent to which they were prepared to subscribe to this approach in the first place – as a condition of their epistemological-pedagogical viewpoints. Teachers were unused to self-autonomy in selecting learning tasks and so tried to do everything – as the pilot proceeded they became far more selective often on the basis of sound educational outcomes.
Dunkerton analysed students' visit/issue reports over the period of the SNAB pilot and found that improvements were in descriptive rather than analytical components (Dunkerton, 2007). Many

students found it difficult to write full evaluations or discussions of their visits. This links to Lewis' findings that SNAB teachers found classroom discussion requirements difficult and particularly encouraging students to adopt a more critical approach to handling information.

2.8. Summary and concluding remarks

In the last ten years there has been diversification of research on impact of context-based science teaching. Firstly there has been an extension to the location of studies, reflecting increasing interest in countries outside the loci of effort identified in the York EPPI review, for example in Korea (Lee and Erdogan, 2007), Colombia (Castano, 2008), Germany (Parchmann and Luecken, 2010), Sweden (Ottander and Eckborg, 2011) and Portugal (Santos and Braund, 2009). Secondly there has been a widening of the areas of impact studied from those mainly looking at effects in terms of student performance and attitudes to encompass studies on development of students' discussion and argumentation and the extent of change in teaching repertoires of those involved in teaching context-based and STS approaches. To a certain extent this has reflected broader trends in education research but it also marks a continuing and strengthening research effort in the field.

The consensus on the strength of evidence on impact of context-based and STS approaches is that there is good evidence that students' knowledge and understanding is not less than students who have followed conventional concept-led approaches. There is strong evidence that students' interest in science, their motivation in the subject and the possibility that they might continue studying science subjects are improved by having followed context-based or STS approaches, particularly when exposed to longer duration enrichments, interventions and whole courses. There is some evidence that teachers change their teaching behaviours to encompass more student-centred activity but that they might be more reticent about using discussion and argumentation particularly when these address controversial or ethical issues. As a consequence, although there is evidence to show that some students improve their skills in critical thinking and argumentation as a result of context-based teaching, there is probably some way to go in getting the most from classroom discussion. The intentions of those who designed and developed context-based courses, that teachers will change to using more student-centred teaching and active learning, may be a rather distant goal. There is evidence that teachers trying to teach in context may adopt a 'business as usual' approach where, although the contexts of science are visible to the students, teaching styles have hardly changed.

3. Methodology

The study used a mixture of quantitative methods to analyse examination results at different levels (whole exam and by units and for one question), for different teaching approaches, and qualitative methods to collect and analyse information provided by teachers.

3.1. Sampling

Data were made available by Edexcel for 564 UK centres entering candidates for GCSE A-Level Biology in 2010. Centres comprised a variety of institutions including schools in the private and public sector, sixth form colleges, FE and tertiary colleges and tutoring organisations. Centres were excluded from the analysis if they had fewer than five entries in the 2010 exam, reducing numbers of centres to 355. This decision was made on the basis that centres with fewer than five entries may not be schools and may therefore be delivering teaching (if at all) in a substantially different way to the school or college based centres that are the focus of this research.

3.2. Identification of teaching approach

Efforts were made to categorise the 355 centres on the basis of the teaching approach they used for the 2008-2010 cohort of students: context-SNAB, concept, or a mixture of approaches. It should be noted that Edexcel does not collect or hold data on teaching approach used. Centres were contacted by Email and asked which of these three approaches was predominantly used. In effect, several sources of information were used to come to the most reliable judgement on teaching approach that could be made:

1. In some cases, direct reports of approach, from Emails and personal communication, were available from schools. In these cases, schools were categorised according to these reports.

2. In some cases, where direct reports were not available, the Science Education Group at York (UYSEG) had records detailing whether centres had previously delivered SNAB teaching, had attended training courses or signed up to receive information about SNAB. Where these sources did not clash with other information (for example where UYSEG had a centre recorded as SNAB and where there was no conflicting evidence that the school had purchased non-SNAB [concept] resources), schools were categorised as context-SNAB according to this information.

3. For schools where neither of these sources of information in 1 and 2 above were available or adequate, centres were more loosely categorised based on their previous history of examination entries in 2008 and 2009 (Context-SNAB or traditional/concept) and on the textbooks purchased from Pearson–Edexcel in 2008 which would tend to indicate possible teaching approach for the 2008-10 cohort. Thus schools purchasing only SNAB (orange) textbooks for both teachers and students were seen as likely to be context-approach schools and schools purchasing only concept (green) textbooks were most likely to be following a concept-based approach. Where schools bought textbooks and teacher materials from both approaches they could have been categorised as mixed approach. It was recognised that this

level of proxy for teaching approach based on resources purchased is much weaker than others above and was only used to support decisions based on more robust sources.

4. Where the steps outlined in 1-3 above could not be used to identify the teaching approach used, further efforts were made to contact schools by Email and by telephone.

5. Schools categorised as using a mixed delivery, where numbers of students entered suggested there may be multiple class groups, were contacted to check whether delivery was mixed overall for all groups or was organised as one group following a context-SNAB route and another following a concept one. All responding schools indicated their teaching approach was mixed within all classes or sets.

Based on steps detailed above, categorisations of schools on the basis of teaching approach were possible for 344 of the 355 centres submitting 5 or more candidates for Edexcel Biology A-level in 2010. These categorisations, along with the number of students within each category, are presented as **Table 3.1**. Context-SNAB schools were better represented in the sample than concept or mixed schools and SNAB students even more so (indicating that the context-SNAB schools may have constituted a higher proportion of the entry than concept schools). Whether this reflects a true population difference for the whole population of students entered for Edexcel A-level Biology in 2010 or was due to sampling methods is unclear.

Table 3.1: Categorisation of schools

Teaching approach	Number of centres (%)	Number of candidates (%)
Concept	123 (35.8)	2157 (28.5)
Context-SNAB	195 (56.7)	4682 (61.9)
Mixed	26 (7.6)	722 (9.5)

Centre level data were merged with pupil-level data, to provide details of students within schools. Variables on the level of the student included standardised marks and grades for overall A levels, and for the units and questions within units contributing to the overall mark. Data on GCSE attainment was also available at the student level.

3.3. Analysis of student performance data at the level of the whole examination

To answer research question one, on student performance differences due to teaching approach, examination data for centres (marks for the whole examination out of a total of 600) were subjected to bivariate tests (*t*-test and χ^2) to compare performance of students following a context-SNAB approach and a concept approach. To include the third category of the independent variable, a mixed delivery approach, an analysis of variance, ANOVA, was used. The effect sizes of any noticeable differences between approaches were calculated.

To examine grade distributions across all three teaching approaches in addition to scores, crosstabs producing χ^2 statistics were used. To simplify this and ensure adequate group sizes, grades were examined on a binary distinction between those getting below C grades compared to those getting C grades or above for the three different teaching approaches.

The impact of teaching approach, controlling for GCSE points score (a score on a continuous scale based on GCSE attainment), was examined using linear regression. Mean points for GCSE scores are based on a points system where students receive 8 points for an A* grade, 7 for an A grade, and so on. Total points are summed and divided by the total number of GCSEs to arrive at a mean score. Linear regression analysis was used to test whether differences between context-SNAB and concept approaches and between either or both these approaches and a mixed delivery approach remain when previous academic achievement is factored in. Four models for linear regression were tested, using different predicting variables:

- just teaching approach;
- contrasting context-SNAB and concept with mixed approaches as the comparison group;
- just teaching approach with non-mixed (i.e. context-SNAB and concept approaches combined) as the comparison group;
- teaching approach; contrasting context-SNAB and concept to mixed approach with GCSE points score and finally a mixed teaching approach with GCSE points score.

To answer research question two, comparing student performance with previous GCSE scores, students' mean GCSE scores were obtained from nationally available public data. These data were used to divide the cohort and allocate students to performance pentiles. To compare all three approaches – context-SNAB, concept and mixed - the proportion of students from each pentile achieving A*-C versus below C grades at A-level was examined.

3.4 Analysis of student performance data at UNIT and question level

Similar tests, as those described in the last section, were applied at the level of scores for different components (units) of the examination (see **Table 1.2** and **ANNEXE A**). The significance levels and effect sizes for any differences between approaches were calculated.

One question on the A-level paper, question 7 from UNIT 5, involved students responding to a pre-released text, reflecting the context-based focus of the SNAB approach. The hypothesis that context-SNAB students might out-perform students who followed other teaching methods on this question was tested. The same methods as above were used – differences in mean scores were tested using *t*-tests and ANOVA, and regressions were run again to control for GCSE performance.

A total of 30 marks were available for this question and, based on a visual assessment, marks appeared normally distributed with a slight positive skew and so parametric tests on these data were considered valid.

3.5 Completion rates

To answer research question four, on AS to A2 completion rates for different teaching approaches, data were collected on the number of candidates starting biology A-level and the number of candidates who completed all six modules. Several limitations exist in these data, including:

- It is not clear why those who did not complete the full A-level did not do so. These candidates may have dropped out, or may never have planned to do a complete A-level and so left after completing AS level.

- Data for this section of the report are based on candidates who completed all modules, whereas data in the rest of the report are based on those who 'cashed in' their modules. This has resulted in a small difference in numbers for some schools.

Therefore, findings should be interpreted as an indicator rather than a direct measure of whether teaching approach impacts non-completion.

Rates of non-completion were calculated for each centre, based on dividing the number of candidates who completed a full A-level in Biology by the number of candidates who began the course (according to data supplied by Edexcel). ANOVA was then used to explore whether there were statistically significant differences between the teaching approaches in terms of non-completion rates.

3.6 Collection and analysis of qualitative data from teachers

To answer research question three, about school-based factors impacting student performance in A-level biology, the heads of biology departments in all 344 centres in the study were sent a 15 item questionnaire asking for rated opinions on strength of impact of factors affecting students' performance in A-level Biology and information about their teaching approaches.

The first set of questions explored, using a four point scale, how teachers felt various factors (students' previous attainment, Y11 teaching, teachers' experience at A-level, CPD, assessment methods) impacted students' performance in the 2010 examination. A second set of questions explored the extent to which certain teaching approaches had been used, again using a four point scale to measure the extent of teachers' agreement. One open question was included at the end of the questionnaire, asking teachers to nominate the most important factor impacting student performance in the 2010 examination. ANNEXE B contains the full questionnaire.

There was a satisfactory response rate for returns of questionnaires (N=106: 31%) allowing the research team to select schools for follow up in-depth interviews (on the basis of these returns and mean examination results for the different approaches).

Twenty-four schools were selected for potential interviews with the head of biology from the subset of 106 schools that returned questionnaires. Heads of biology were chosen as it was considered they would be in the best position to provide reliable information on teaching, resource use and approaches for all teachers involved in A-level biology teaching in a school. It is possible that

respondents were not necessarily a fully representative sample of schools, reflecting mainly those teachers (in about one third of schools) who were engaged and motivated enough to respond to the questionnaire in the first place.

Initially, four schools were approached for each of the three teaching approaches, two in schools whose students scored above the mean for each teaching approach and two in schools whose students scored below it. As the team were especially interested to explore how schools used a mixed approach, teachers in a further four of these schools were interviewed, bringing the interview total to sixteen. ANNEXE C shows the script of semi-structured interview with the researcher. Interviews were audio recorded and transcribed as word documents with line numbers. Two researchers independently examined and coded all sixteen transcripts according to codes they saw emerging from responses. Inter-researcher agreement on coding decisions was high, at 85%.

4 Findings 1. Analysis of student performance data for Edexcel A-level biology in 2010

A note on statistical terms

Throughout this section of the report, various statistical terms are used. This note describes how these are interpreted.

- p values refer to the statistical significance of findings. By convention, p values of less than 0.05 indicate that findings are statistically significant. The value is set at a level of confidence above a 95% probability that any effect is not due to chance alone. Where p values are higher than 0.05, this means that findings are not statistically significant and findings are more likely to be due to chance. In these cases figures are marked as NS (not significant).

- *t*-test statistics are used to test for differences between two samples or groups within a sample. The value of the *t* statistic is not used in isolation here, but an effect size is provided alongside it to aid interpretation.

- F statistics are similar to *t* statistics but are used to examine the differences between more than two groups. F is calculated based on both the variance between the means of the different groups, and the mean of the variance within the groups of interest. Where F statistics are reported, charts showing the different means are also provided.

4.1. Analysis at the level of the whole examination

***t*-test**

No statistically significant difference was found between student performance in terms of mean marks (out of 600) at GCE A-level for those following the context-SNAB and concept approaches. Results are shown in **Table 4.1**. Effect sizes for student's *t* tests are presented throughout, calculated based on the difference in means divided by the standard deviation for all in the first group (so using table 2 as an example, difference in means=1, standard deviation for concept students=89.0, so effect size=1/89.0=0.01).

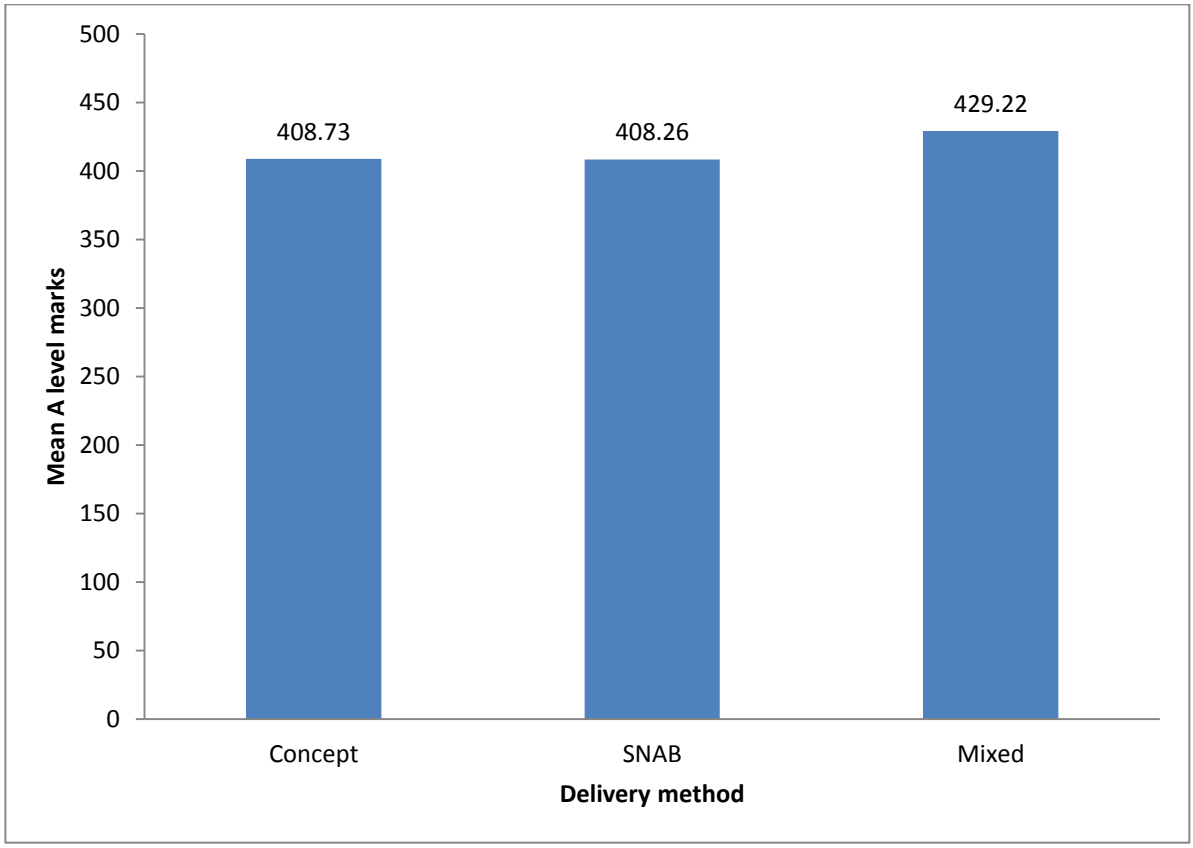
Table 4.1. *t*-test comparing mean marks for SNAB and concept students

Teaching approach	Mean mark	*t*	Effect size
Concept	408 (SD=89.0)	-0.4 NS	0.01
SNAB	409 (SD=90.1)		

ANOVA

To include mixed delivery in the analysis, ANOVA was used. This time a statistically significant difference was found between the three delivery methods with students experiencing a mixed delivery approach gaining higher marks than those experiencing either context-SNAB or concept approaches alone (mean for mixed delivery participants=432; F=22.8, p<0.001). Results are shown in **Figure 4.1.**

Figure 4.1. : Mean A-level marks by teaching approach



The effect size of the difference for the mixed approach over the context-SNAB or concept approaches was 0.27. This was calculated using a *t*-test comparing mixed with non-mixed delivery (*t*=-6.7, mean [non-mixed]=408, mean [mixed]=432, sd [non-mixed]=90.1). According to analysis of studies in educational settings quoting effect sizes (see, for example: Hattie, 2009; Coe, 2002) an effect size of 0.25 is worth noting. An effect size of 1.0 is huge and would translate, at GCSE level, to a difference of about two grades, so an effect size of 0.25 is equivalent to about half of one grade advantage. It should be noted that the literature on effect sizes has not yet reported clearly enough effects in terms of A-level grades.

CROSSTABS

A-level grades, in addition to mean marks, were examined using crosstabs. Differences were found to be statistically significant using Chi² tests (χ^2=62.2 p<0.001). **Table 4.2**. shows the percentage of students in each category. Again, context-SNAB and concept delivery approaches achieved very similar distributions across the range of grades, with mixed delivery approach students being somewhat more likely to get higher grades and less likely to get lower grades. Cells where the count for number of schools is less than 30 are highlighted as these may not be stable due to the small numbers of students involved.

Table 4.2. : Crosstabs of delivery method by A level grade

	U	E	D	C	B	A	A*
Concept	3.1	9.3	18.3	23.4	21.0	17.7	7.3
SNAB	3.6	10.2	16.7	21.6	22.3	17.6	8.0
Mixed	1.9	7.1	12.3	17.5	27.0	22.9	11.4
Total	3.3	9.6	16.8	21.7	22.4	18.1	8.1

To simplify this, grades were also examined on a binary distinction between those getting below C grades compared to those getting C grades or above. Results are shown in **Table 4.3**. A statistically significant difference remains based on this breakdown (χ^2=26.7, p=<0.001), again with remarkably similar results between context-SNAB and concept approaches and a higher proportion of students experiencing a mixed approach gaining C grades or above.

Table 4.3. : Crosstabs of delivery method by A-C versus below C grade

	Below C grade	A*-C grade
Concept	30.7	69.3
SNAB	30.5	69.5
Mixed	21.3	78.7
Total	29.7	70.3

Controlling for GCSE scores

The impact of teaching approach controlling for GCSE score was examined using linear regression. This was done in order to test whether differences between SNAB and concept delivery remain when previous academic achievement is factored in.

As expected from previous studies, GCSE scores are the strongest predictor of A-level marks. Entered alone, context-SNAB and concept approach make no statistically significant difference to A-level marks. The first regression, contrasting context-SNAB and concept approaches to the mixed approach, reveals a loss of 23.3 marks for those following a context-SNAB approach and of 24.4 marks for those following a concept approach. Both variables are associated with a statistically significant loss, although the variation explained by the model is less than 1%[1]. Similarly, the second regression reveals that when contrasted with both other approaches, students following the mixed approach gain 23.7 marks – but again, very little variation is explained by approach.

In combination with GCSE marks, a much better model, explaining 48% of the variation in A-level scores, is achieved. However, when contrasted with a mixed approach only context-SNAB retains a statistically significant association with A-level scores, and is associated with a very small loss – only 6.1 marks – compared to mixed. Similarly, a mixed approach contrasted to both context-SNAB and concept is associated with only a very small gain – of 5.4 marks. It is unlikely that such mark differences taken across the whole examination would have a large impact on examination grades. These results of regression are shown in **Table 4.4**.

Table 4.4. : Regressions exploring the impact of teaching approach on A-level points score

	Just delivery method, mixed as base	Just delivery method, non-mixed as base	Delivery and GCSE score, mixed as base	Delivery and GCSE score, non-mixed as base
Variable	**B**	**B**	**B**	**B**
Mean GCSE score			78.9, p<0.001	78.9, p<0.001
Context-SNAB	-23.3, p<0.001		-6.1, p=0.03	
Concept	-24.4, p<0.001		-3.9, NS	
Mixed		23.7, p<0.001		5.4, p=0.05
Adjusted r^2	0.01	0.01	0.48	0.48

Exploring A-level grades by GCSE pentile

To compare all three approaches – context-SNAB, concept and mixed – the proportion from each pentile of students, worked from GCSE mean points scores, achieving A*-C grades at A-level versus below C grades was examined. There were very similar proportions (percentages) of students achieving grades A-C for each pentile for the context-SNAB and concept approaches. Indeed slightly more students from the highest GCSE pentile obtained A*-C grades for the context-SNAB approach

[1] In linear regression, the adjusted r^2 can be interpreted as a proportion of the variation in the dependent variable explained by the model. So in this example, the adjusted r^2 of 0.01 can be multiplied by 100 to give the proportion of variation in A-level marks explained by teaching approach – in this instance, 1%.

(99%) than for the concept approach (97.8). These results challenge the perception that it is mainly candidates of lower previous attainment at GCSE who benefit most from a context-based approach. Students of all abilities do just as well at A-level following either of these approaches. Students who followed the context-SNAB approach obtained the same proportion of the highest grades, A* and A, as did those who followed the concept approach. About 10% more candidates gained A*-C grades within the mixed approach than within either concept or context-SNAB approaches. However, a higher proportion of candidates in the lowest GCSE results pentile failed to gain A-C grades within the mixed approach – about 77%. Results are shown as **Table 4.5**.

Table 4.5. : Achievement of A*-C grade at A-level for each GCSE pentile and for the three teaching approaches

	Teaching approach								
	Concept			SNAB			Mixed		
GCSE Pentiles	<C	C-A*	Total	<C	C-A*	Total	<C	C-A*	Total
Lowest	67.2 (264)	32.8 (129)	100.0 (393)	69.3 (583)	30.7 (258)	100.0 (841)	77.3 (51)	22.7 (15)	100.0 (66)
2nd lowest	42.2 (159)	57.8 (218)	100.0 (377)	46.5 (390)	53.5 (449)	100.0 (839)	40.0 (50)	60.0 (75)	100.0 (125)
Middle	26.1 (99)	73.9 (281)	100.0 (380)	26.0 (221)	74.0 (629)	100.0 (850)	17.7 (22)	82.3 (102)	100.0 (124)
2nd highest	8.3 (28)	91.7 (310)	100.0 (228)	8.1 (81)	90.9 (806)	100.0 (887)	6.4 (9)	93.6 (132)	100.0 (141)
Highest	2.2 (8)	97.8 (360)	100.0 (368)	0.9 (7)	99.1 (802)	100.0 (809)	0.0 (0)	100.0 (180)	100.0 (180)
Total	30.1 (558)	69.9 (1298)	100.0 (1856)	30.3 (1282)	69.7 (2944)	100.0 (4226)	20.8 (132)	79.2 (504)	100.0 (636)

Controlling for type of school: selective or non-selective

Towards the end of the research project Edexcel were able to supply data on school type. Examination data were tested for whether schools being selective interacted with choice of teaching approach and with the impact of approach on student achievement. Edexcel data showed 21.5% of the 344 schools in the sample (74) were selective (including state /grammar and independent schools). Similar proportions of pupils attended selective schools, suggesting that these schools

entered, on average, a similar number of candidates to other schools in the sample – 22.1% of pupils went to selective schools.

However, differences were more pronounced when looking at the type of teaching approach schools were likely to follow. **Table 4.6** shows the proportion of schools following each teaching approach. Selective schools were almost four times more likely than non-selective schools to follow a mixed approach.

Table 4.6. : Teaching approach by selective status – percentages (numbers are in brackets)

	Concept (n)		Context (n)		Mixed (n)	
	Schools	Pupils	Schools	Pupils	Schools	Pupils
Not selective	37.0 (100)	30.0 (1784)	58.2 (157)	64.5 (3801)	4.8 (13)	5.4 (320)
Selective	31.1 (23)	23.3 (390)	51.4 (38)	52.7 (881)	17.6 (13)	24.0 (402)

Table 4.7. shows column percentages for the proportion of schools within each teaching approach that were selective or non-selective. While just under 20% of concept or context schools were selective, more than twice as many, 50%, of mixed schools were.

Table 4.7. : Percentages of students in selective and non-selective by teaching approach

Centre type	Concept	Context	Mixed
Non-selective	81.3% (100)	80.5% (157)	50% (13)
Selective	18.7% (23)	19.5% (38)	50% (13)

Table 4.8. shows the mean A-level marks by teaching approach and whether schools were selective or not. Marks across the approaches were very similar within selective and non-selective schools, but were markedly different between selective and non-selective schools, irrespective of the teaching approach. ANOVA tests were run to see whether within non-selective and selective schools, teaching approach was associated with different marks. Results were not statistically significantly different for non-selective schools ($F=0.98$, $p=0.375$) or within selective schools ($F=0.49$, $p=0.615$). *t*-tests were used to calculate effect sizes for differences between approaches, and were found to be very small:

- Within non-selective schools, the effect size for a concept approach was <0.01, for a SNAB approach it was 0.02, and for a mixed approach it was 0.08.

- Within selective schools, the effect size for a concept approach was 0.06, for a SNAB approach it was 0.03, and for a mixed approach it was 0.02.

Table 4.8. : Mean A-level marks for the teaching approaches by school type

Centre type	Concept	Context	Mixed
Non-selective	398.6	398.4	405.5
Selective	447.9	452.7	452.9

The bias of the higher proportion of selective schools for the mixed approach was reflected when regressions were re-run controlling for the selective status of the schools. Where previously context and concept approaches were associated with a small drop in marks compared to mixed, and mixed was associated with a small gain in marks compared to both other teaching approaches together, none of these factors remained statistically significant when the selective status of schools was controlled for. Attending a selective school is associated, once previous GCSE scores are controlled for, with an increase of about 13 marks. Results are presented in **Table 4.9**.

Table 4.9. : Regressions controlling for selective schools

	Concept and context vs mixed	Mixed vs other approaches
Variable	B	B
Mean GCSE score	77.2 p<0.005	77.2 p<0.005
Context-SNAB	-1.7 p=0.559	
Concept	0.5 p=0.880	
Mixed		1.0 p=0.716
Attending a selective school	12.8 p<0.005	12.8 p<0.005
Adjusted r^2	0.48	0.48

4.2. Analysis of student performance at the unit and question level

Mean marks for each unit

Marks were examined by teaching approach for each UNIT of the A-level examination (for an explanation of each unit, its content and how it is assessed see ANNEXE A). Statistically significant differences based on teaching approach were found for each unit. For the most part, the greatest

difference was between mixed and the other two approaches. For units 1, 2, 4 and 5, a mixed approach results in higher student marks. For unit 3, context-SNAB and mixed approach students out-perform students following a concept approach. Finally, for unit 6, context-SNAB students outperform concept students, but are themselves outperformed by mixed delivery students. However, the apparent advantages for mixed approach disappear once the type of school (selective or non-selective) is controlled for.

Table 4.10. : Mean marks for each unit by delivery method

Unit	Mean (Concept)	Mean (SNAB)	Mean (Mixed)	F
1	90.5	89.7	94.1	19.4, p<0.001
2	87.3	86.4	91.5	21.8 p<0.001
3	40.9	42.1	42.1	16.8, p<0.001
4	79.4	79.5	84.8	14.3, p<0.001
5	70.9	70.1	76.2	15.8, p<0.001
6	38.6	40.8	43.2	67.4, p<0.001

To examine effect sizes for these differences, various *t*-tests were run. For units 1, 2, 4 and 5 mixed was contrasted to other delivery types. For unit 3 context-SNAB and mixed were contrasted to concept. Finally, two *t*-tests were run for unit 6 – comparing context-SNAB with concept, then comparing mixed with context-SNAB.

For all units, a reasonable effect size was found between mixed and other approaches (ranging from 0.21-0.25). Results are shown in **Table 4.11**.

Table 4.11. : Mixed compared with other delivery types

Delivery method	**Mean mark**			
	Unit 1	**Unit 2**	**Unit 4**	**Unit 5**
Not mixed	89.9 (sd=18.0)	86.7 (sd=19.2)	79.4 (sd=25.6)	70.4 (sd=27.3)
Mixed	94.1 (sd=17.7)	91.5 (sd=18.0)	84.8 (sd=24.5)	76.2 (sd=26.2)
t	-6.1, p<0.001	-6.3, p<0.001	-5.5, p<0.001	-5.7, p<0.001
Effect size	0.23	0.25	0.21	0.21

For unit 3, a small effect size was found between concept and context-SNAB approach. Results are shown in **Table 4.12.**

Table 4.12. : Concept compared with other approaches for unit 3

Delivery method	**Mean mark**	***t***	**Effect size**
Not concept	42.1 (sd=8.6)	5.9, p<0.001	0.14
Concept	40.9 (sd=40.9)		

For unit 6, a reasonable effect size was found between context-SNAB and concept approaches (shown in **Table 4.13**), and between context-SNAB and mixed approaches (shown in **Table 4.14**).

Table 4.13. : SNAB compared to concept for unit 6

Delivery method	**Mean mark**	***t***	**Effect size**
Concept	38.6 (sd=10.1)	-8.5, p<0.001	0.22
SNAB	40.8 (sd=10.2)		

Table 4.14. : SNAB compared to mixed for unit 6

Delivery method	**Mean mark**	***t***	**Effect size**
SNAB	40.8 (sd=10.2)	-6.2, p<0.001	0.24
Mixed	43.2 (sd=9.6)		

Thus, in conventionally examined units, a positive effect in favour of students following a mixed teaching approach is seen. In units where the teacher has some control over content and input for students there is still some advantage for mixed approach students but this advantage is also evident for students following a context-SNAB approach over those taught using more traditional concept-led methods. Again, these apparent positive advantages for the mixed approach disappear once school type is controlled for.

Context question

One question on the A-level paper involved responding to a pre-released text, reflecting the focus on the SNAB approach. The hypothesis that SNAB students would out-perform students from other delivery methods on this question was therefore tested.

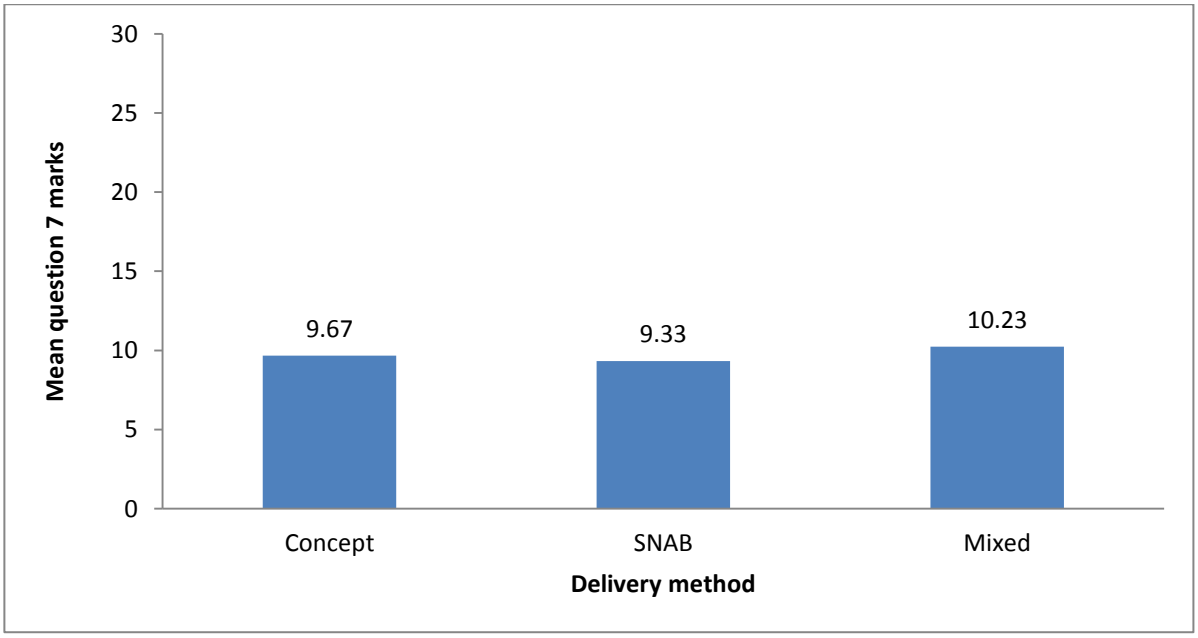
No statistically significant difference was found between context-SNAB and concept students' marks on this question. Results are shown in **Table 4.15**.

Table 4.15. : *t*-test showing the difference in marks on the context question based on SNAB vs Concept

Delivery method	Mean mark	*t*	Effect size
Concept	9.6 (sd=4.7)	1.9 NS	0.04
SNAB	9.4 (sd=4.5)		

As seen in other analyses, a larger difference was evident between marks of both context-SNAB and concept approach students, and students taught through a mixed approach. Those experiencing a mixed delivery approach scored higher than both other groups, with a mean of 10.4 – 0.8 marks higher than those on concept delivery and 1.0 higher than context-SNAB. Differences are shown in **Figure 4.2**. Differences (measured using ANOVA) were found to be statistically significant (F=12.0, p<0.001).

Figure 4.2. : Mean marks on the context question by teaching approach



Similar regressions to those used at the whole examination level were run based on marks for this 'context' question. Here, when context-SNAB and concept approach are contrasted to a base of mixed delivery, both result in a loss of 1 mark (context-SNAB) and 0.7 marks (concept approach). In column 2, where mixed approach is contrasted to the other types, a gain of 0.9 marks is found. However, the effect of approach is eliminated when GCSE mean scores are entered into the regressions. Results are shown in **Table 4.16**.

Table 4.16. : Regressions exploring the impact of delivery method on context question marks

	Just delivery method, mixed as base	Just delivery method, non-mixed as base	Delivery and GCSE score, mixed as base	Delivery and GCSE score, non-mixed as base
Variable	**B**	**B**	**B**	**B**
Mean GCSE score			2.9, p<0.001	2.9, p<0.001
SNAB delivery	-1.0, p<0.001*		-0.4, NS	
Concept delivery	-0.7, p=0.001		-0.0, NS	
Mixed delivery		0.9, p<0.001		0.26, NS
Adjusted r^2	0.00	0.00	0.25	0.25

4.3. Completion rates for different teaching approaches

Rates of non-completion were calculated for each centre, based on dividing the number of candidates who completed an A level in Biology by the number of candidates who began such an A level (according to Edexcel data). ANOVA was then used to explore whether there were statistically significant differences between the teaching approaches in terms of drop-out rates. The overall mean non-completion or 'dropout' rate was 57%. For those following a concept teaching approach, the rate was 59%, and for those following a context approach it was 56%. For those following a mixed approach, the drop-out rate was 60%. These rates were not found to be significantly different (F=1.3, p=0.3).

5 Findings 2. Data collected from teachers (Heads of Biology)

5.1 Findings from the teacher questionnaire

106 responses were received to the survey which was sent out to the 344 schools included in the statistical analysis. Responses were not equally distributed between the approaches – 26 were received from concept schools, 69 from context-SNAB schools, and 11 from mixed approach schools. The very low numbers from mixed approach schools indicate that any differences found in statistical analysis of the returns should be treated with a great deal of caution.

5.1.1. Factors explaining student success in A-level biology

Using cross-tabs for teaching approach and the response frequencies for responses on the 4-point scale, very small cell sizes were found. Therefore, results were grouped into *not important* which combined 'not at all important' and 'not very important' responses and *impor*tant which combined 'important' and 'very important' responses. No statistically significant differences were found between schools following the different approaches as to how important they rated each factor. The vast majority of teachers across all three teaching approaches rated previous attainment, teacher experience, and school assessment and monitoring as important. A slightly lower, but still high proportion, across teaching approaches rated professional development, either general or provided by Edexcel, as important. A somewhat lower proportion, although still greater than half teachers irrespective of teaching approach, rated the teaching approach taken in year 11 as important. Results are shown in **Table 5.1.1.**

Table 5.1.1. : Ratings of different factors in explaining student success at A-level

	Not important	**Important**	**Chi²**
Previous attainment in biology			
Concept	7.7	92.3	5.7 NS
SNAB	5.8	94.2	
Mixed	27.3	72.7	
Total	8.5	91.5	
Teaching approach in year 11			
Concept	30.8	69.2	0.2 NS
SNAB	35.3	64.7	
Mixed	30.0	70.0	
Total	33.7	66.3	

Teacher's previous experience			
Concept	0.0	100.0	1.9 NS
SNAB	5.8	94.2	
Mixed	9.1	90.9	
Total	4.7	95.3	
Professional development (all)			
Concept	15.4	84.6	0.9 NS
SNAB	8.7	91.3	
Mixed	9.1	90.9	
Total	10.4	89.6	
Professional development (Edexcel)			
Concept	26.9	73.1	3.8 NS
SNAB	11.6	88.4	
Mixed	9.1	90.9	
Total	15.1	84.9	
School assessment and monitoring methods			
Concept	3.8	96.2	0.8 NS
SNAB	5.8	94.2	
Mixed	0.0	100.0	
Total	4.7	95.3	

5.1.2. Teaching approach

As above, for factors impacting success at A-level, responses to the questions relating to teaching approach were organised into two categories – 'strongly disagree' and 'disagree' were aggregated into *disagree*, while 'agree' and 'strongly agree' were aggregated into *agree*. Here, statistically significant differences were found between the different teaching approaches for four of the questions. Context-SNAB and mixed approach schools were more likely to agree that storylines were used in teaching. Unsurprisingly, Context-SNAB schools were more likely to report using context-

SNAB (orange) textbooks. Both concept and mixed approach schools were much more likely to use primarily concept (green) textbooks, showing that most of the mixing of textbook use may be from context-based books into an already established culture of concept resources, though the numbers are too small to be certain of this.

Over half of respondents from all teaching approaches used a mixture of books, but mixed approach schools were much more likely to use a mixture of books than context-SNAB or concept schools. Differences between teaching approaches were not statistically significant in terms of the remaining questions. Across teaching approaches, a large majority of teachers reported using lab equipment and resources, having teacher experience of exam questions, and using ICT. A slightly smaller, but still large proportion of schools, reported using school visits and fieldwork trips. Results are shown in **Table 5.1.2**.

Table 5.1.2. : Responses to questions relating to teaching approach

	Disagree	**Agree**	**Chi²**
Use of storyline in teaching			
Concept	69.2	30.8	16.4**
SNAB	24.6	75.4	
Mixed	30.0	70.0	
Total	36.2	63.8	
Use of SNAB books			
Concept	84.6	15.4	59.9**
SNAB	5.8	94.2	
Mixed	60.0	40.0	
Total	30.5	69.5	
Use of concept books			
Concept	23.1	76.9	60.4**
SNAB	95.5	4.5	
Mixed	18.2	81.8	
Total	68.9	31.1	

Use of a mixture of SNAB and concept books			
Concept	46.2	53.8	6.9*
SNAB	38.2	61.8	
Mixed	0.0	100.0	
Total	36.5	63.5	
Lab equipment and resources			
Concept	0.0	100.0	2.3 NS
SNAB	2.9	97.1	
Mixed	9.1	90.9	
Total	2.9	97.1	
School visits and fieldwork trips			
Concept	26.9	73.1	0.3 NS
SNAB	30.4	69.6	
Mixed	36.4	63.6	
Total	30.2	69.8	
Teacher experience of exam questions			
Concept	0.0	100.0	2.4 NS
SNAB	8.7	91.3	
Mixed	9.1	90.9	
Total	6.6	93.4	
Use of ICT			
Concept	15.4	84.6	2.6 NS
SNAB	10.1	89.9	
Mixed	27.3	72.7	
Total	13.2	86.8	

5.1.3. Teachers' perceptions of important factors impacting student performance in Edexcel A-level Biology in 2010

The final item of the teacher questionnaire was an open question, asking teachers to nominate the most important factor, as they perceived it, impacting student performance for the 2010 examination. The responses were categorised and are shown as Table 5.1.3. The following patterns were noted:

- Only half of respondents provided details – maybe most of the factors were covered by the first 14 question items or they did not wish to answer the question.

- Of those responding, most frequent factors were connected with assessment, most often to support examination practice

- There was an interesting variety of responses concerned with teaching and teacher factors, (more so than for pupil factors). Teachers' knowledge or experience of examinations is seen as important.

- Resources to support learning included: effective uses of SNAB-online, own designed ICT and effective use of both types of textbook and revision guides.

- Some negative factors included: lack of time for teaching or to engage with visits and fieldwork. Eleven respondents volunteered information complaining about the Edexcel examination (question type, overload of course work, unchallenging questions and poor match of questions to specification).

- 5 schools mentioned benefits of additional out-of-school visits (beyond those to support examination requirements in UNIT 3) e.g. to universities for lectures or revision lessons.

Table 5.1.3. Responses to open question, 'Factors that might have helped your biology students achieve success in the 2010 Edexcel examination? (106 responses)

Category	Sub-category	Freqy
Out of school	Contact with parents	1
	Visits (e.g. to universities)	3
Assessment	Use of examination questions	22
	Structured (regular)testing	1
	Individual (monitored) target setting	6
	Lessons linked to assessment	1
	Regular feedback to students	2
Resources	Good use of SNAB online	3
	Additional ICT resources (non SNAB)	3
	Good use of both book types	3
	Targeted use of concept resources (for rote learning certain topics)	1
	Revision guides	4
Teaching	Experienced/enthusiastic staff (e.g. acting as moderator or AST)	5
	Good SKN of staff	1
	Good KN of exams	4
	Good relationships with pupils	3
	1 to 1 tutoring	1
	Concentration on HSW and /or graphing	2
	Teach practical skills/ time for practicals	4
	Teach exam technique	2
	Make pupils are of unit criteria	2
	Variety of T&L	1
	Use topical biology in news	1
	Good technician support	1
Pupil factors	Good progression from GCSE	1
	Poor progression from KS4 (spoon fed)	1
	Recruit at B and above from GCSE	2
	Independence /good work ethic/motivation	3
Negative factors	Reduced contact/teaching time	1
	No time for visits/fieldwork	1
	Problems with exam board	5
	Mismatched AS and A2 demands	1
	Poorly differentiated or unchallenging exam qus.	2
	Poor match of questions to content	3
Others	Post 2010 factors	2
	No response	48

5.2 *Findings from interviews with teachers*

In the report of findings from interviews, quoted extracts from transcripts are coded according to the teaching approach of the school interviewed, whether or not they were a selective school or college and if they had students who scored well above or well below the mean mark for the teaching approach. Following the code are numbers indicating the lines of the transcript from which an extract was taken.

Thus the code:

MLNS/108-13: refers to lines 108-113 taken from an interview with a teacher (Head of Biology) in a non-selective school following a mixed teaching approach whose students scored below the mean for this approach.

Codes: CP = Concept approach; CX = context (SNAB) approach; M = Mixed approach; H = Students performing above the mean for the approach; L= students performing below the mean for the approach; FE = a college or sixth form operating in the Further Education sector.

5.2.1 Experience of teaching teams

All schools interviewed had teaching teams led by heads of biology with significant experience of teaching A-level (+5 years). In most teams there was a mix of A-level experience, with concept approach and mixed approach schools having a higher mean of years' experience than context schools (5.2 years in context schools compared with 8.5 years and 9.3 years, respectively, for concept and mixed approach). Additionally in 3 of the 4 context schools interviewed there were NQTs teaching A-level classes while in concept schools this figure was 2 out of 4 and in mixed schools it was only 1 out of 8 schools.

Taken together these outcomes suggest it is possible that concept and mixed approach schools have more experienced A-level biology teachers than context-based schools. However, it may have been that schools selected for interviews and returning questionnaire responses were not a representative enough sample for any confident conclusions about relative experience of teams to be drawn. However, we have a little more confidence in noting that teams in mixed schools are among the more experienced ones at teaching A-level Biology. This could be associated with the higher number of selective schools for the mixed approach, though generally we did not find evidence that teaching teams in non-selective (comprehensive) schools were inexperienced compared with those in independent and selective/grammar schools. Teachers' experience and confidence are likely to play an important part in their abilities to select, from a range of available resources and approaches, those most likely to bring about successes for their students.

5.2.2 Teaching approach and resource/textbook use

There was a tendency in all schools to draw on a mixture of approaches and range of resources, including textbooks, for teaching A-level Biology. The range of use and extent of mixing was greatest in mixed approach schools but this does not mean that context and concept approach schools always stick to one approach or resource. In mixed approach schools it was often a first contact with SNAB

resources that sparked an interest in the possibilities afforded by more varied teaching and resource use, in this case, with a perception of benefit for students.

> *I was teaching AQA at my previous school … you know, it is a different way of doing it* (in Edexcel) *and you start with the text book and you think hmm ... and I have now gone through my Power Points and set it much more in a context and used the same context for the cystic fibrosis things as they do in that book* (the orange SNAB book)*, and the kids have been much more motivated.*
>
> MLS/72-4, 82-5

> *We went to a feedback meeting from examiners at xxxxx school and it was really then that we heard about the orange books. So we had just the green books which they* (students) *have individually … so we bought class sets or half class sets* (of the orange context book) *so they could use it to supplement their work in class … and they are lovely, we couldn't do without them now.*
>
> MLNS/50-7

In the case quoted below, a teacher in a mixed approach, non-selective, school could see that a wider choice of materials provided increased flexibility and autonomy for teachers.

> *I went to the launch of the Edexcel course in 2008 … the concept and the context thing and the guy actually said, "there, look you can mix it up if you want" … and I like the idea of having the freedom to do that, you know, and not to be told to have to do it in a particular way.*
>
> MHNS/147-152

In another mixed approach, selective, school the teacher made this perceptive comment about the value of using a mixed approach to promote effective and responsible future learning of students in biology:

> *I very strongly believe that nowadays students need to be taught to find reliable information, and actually relying on one source, one textbook is not ideal. So whilst I have the text books to support the students, I actually try and encourage them to use other things, and then, you know, the text book is the fail safe, if all else fails and they are still struggling then I can look at that to see if it helps me to understand. So I am looking do we buy in some general A level Biology books and actually encourage them to be looking through it, pulling out what they need rather than having a book that is laid out in exactly, you know, they literally can work through from page to page, and there is no development of their research skills or that. And obviously for the course work components at both AS and A2, research plays a big role in it. Committing them to one text book isn't serving them well for the course and for their future biology studies.*
>
> MHS/140-153

The perceived advantages for drawing on a mixture of resources and approaches were often associated with the concept or process being taught, demands of the examination, teachers' preferred methods and their previous experiences and expertise in resource selection.

5.2.2.1 A targeted approach

An emerging theme in about half the schools interviewed was that resources, mainly textbooks, were often used in a targeted way depending on the topic content being taught or the depth of coverage provided. For example in one school, using a context-based approach, the biology teacher felt that the normally favoured context approach required the teacher to act as facilitator but that this might be replaced by more direct teaching of concepts where the biological processes (respiration and photosynthesis in this case) were perceived to require this.

> *… So* (we are) *combining very much a facilitative context approach and then the more challenging concepts, we teach them conceptually. So things like … respiration, photosynthesis, where we feel that there's very much a logical flow, which rests hugely on understanding the processes rather than just being able to work them through … with the teacher as a guide or a facilitator.*
>
> CX/HS/44-9

In one mixed approach selective school, concept (green) textbooks were used where 'rote learning' of certain content was seen as necessary.

> *So we teach… students rote learn … and so we teach specific concepts in a specific way, like … mitosis, respiration … for the students to rote learn the material from the content books … and then we use the Nuffield approach in another way,*
>
> MHS/65-70

There was a perception in a few schools that treatment of topics in the context (orange) textbooks might not be at sufficient depth to support student learning and so the concept (green) books could be used in a supplementary way.

> *I mean, I think there are areas the green book does better … for instance all of the cell division section of the green book is better I think. I find … the orange book it's very simple, and it's not clear because it's very simple.*
>
> CXHS/112-116

In the same school the teacher commented that some terms students might meet in the examination occur in the concept (orange) textbooks but not in the context (green) books and so coverage using both provides a kind of 'safety net' for the teacher.

> *We always have the green book to hand so that when we're actually making our own Power Points, we use key words from the green book as we see them coming up. I've noticed for instance that something like epistasis comes up in the green book and it doesn't appear in the orange book, so I've just made a point of teaching something like that, or just bringing it in, so that, hopefully, nothing comes up as a surprise for them in the exam.*
>
> CXHS/94-101

One view, from a non-selective context-SNAB school, was that teachers new to using a context-based approach might not be experienced enough at using these resources to realise the extent of integration and coverage of content in different resources. This teacher, involved with SNAB since the pilot phase in 2003, stressed that:

Yes, in the context books they (the students) *probably haven't got enough content but … some of it is probably that students don't tend to realise, unless you keep stressing it, that the activity sheets and the book are supposed to be going together and what isn't in the book may be on an activity sheets...*

CXNS/89-93

In the specification for 2010 an element addressing ideas and evidence in science and ways in which the community of science operates, known as 'How Science Works', was addressed for the first time. A teacher in a selective school, heavily committed to SNAB, raised this as a possible shortcoming in the context textbooks:

The emphasis on How Science Works is more in that content approach book, isn't it, not in the context-based book, which you know may well have put the first cohort in 2008-2010 at a disadvantage.

CXLS/78-80

It is worth noting that 'How Science Works' (HSW) is presented differently in the SNAB (orange) and concept (green) textbooks. In the SNAB books, HSW is fully integrated within the context being addressed, whereas in the concept approach books, HSW is shown as examples placed in discrete text boxes.

5.2.2.2 Examination influences

In many cases interviews revealed that teachers draw on a mix of resources, including textbooks, to optimise their students' chances in the examination.

Students have the orange books, but I personally dip into them (the green concept books) *because I just feel occasionally exams come up with … some terminology that is used that only appears in the green book, and I have seen it come up in exams so I tend to try and just keep ahead of the game a bit and just try to make sure that I have covered everything that is in both books really.*

CXLNS/50-7

In one case of a selective school, drawing on both types of textbooks was seen as giving students a better chance on questions prepared by different examiners.

You look at the assessment model of all four papers, unit one, unit two, unit four and unit five, they are obviously written by different principles of examiners, and there is no real consistency between the sort of style of question being asked. They have got better, but it would be dangerous to adopt one single approach because our children would be disadvantaged when it came to the assessment.

MHS/91-6

In two non-selective centres, a high performing school using a concept approach and a low performing FE college, both using a mixed approach, there was a perception that students had to be

confident that the content they were exposed to in textbooks would serve them well in answering examination questions:

> *And it can get a little bit confusing for some of the pupils in that we may be talking about this particular idea, this particular piece of information that they need to know, and then there's no evidence of it in the book, and then they get a bit worried about that, "do I really need to know it? It's not in my book, sir, do I need to know it?"*
>
> CPHNS/121-5

In the sequence below it seemed there was a question of previous experiences of students who lacked confidence in being exposed to a variety of sources of information and learning. It may have been that a number of students entering this non-selective FE College came from schools where they were used to having been 'spoon-fed'.

> *T: The common text* (the concept book) *is a little bit harder for some of our students they often prefer to be told.*
> *I: Do they?*
> *T: Yes*
> *I: Is that the sort of tradition they have grown up with, do you think?*
> *T: I would imagine so, and you know you get the question, "is this on the syllabus", that type of comment*
> *I: They want to know exactly what they are being examined on, do they?*
> *T: Absolutely, yes, that is their bottom line really. And you know, in the end they are judged on that exam so you can see why they do that but we do try to broaden it so that they get a better feel and then they can cope with the more demanding questions.*
>
> MLNSFE/69-92

5.2.3 Teachers' preferred approaches

It was obvious that in many schools there is variation in the amount of context-led teaching used by different teachers in the same school. However, we did not find cases of schools teaching different approaches to different groups of students as groups were usually taught by at least two different teachers.

> *Well each group has two teachers and one of them is an AST and he is pretty out of the box, he doesn't teach in any sort of standard form, he gets amazing results and so he did approach it much more, you know, contextually, which is fine, so really it would be fair to say the class was getting a mix of both just because of the variety of the teachers that were put in front of them.*
>
> CPLNS/70-77

The teacher in this non-selective concept approach school felt the extent that a teacher might use a context approach would depend on their confidence and the extent they were able to go beyond the boundaries of their normal (more traditional) teaching and so take risks.

> *I would say that the contextual approach, you might totally disagree with this … you have to be more totally confident on what you are doing. And I think it takes a lot more risk, risk as in, "oh*

that sounds a bit OTT", but it just takes a lot more experience to just not do it through a conceptual stance.

CPLNS/88-90

In a few cases there was a perception that having another approach, to the one teacher's were previously accustomed, gave a sense of freedom to step beyond adopted teaching.

I am pretty confident that it was probably quite mixed for all of them. It's also because of the teaching staff we had then, they were all quite experienced and they had all taught the old A level which was very, you know, just going through the concepts, so I found it was a good way to introduce the context by allowing them the freedom to give it a go.

MHNS/135-9

It's up to the individual teacher, what works best for them really. I mean we share ideas a lot and we do share groups, so you know, you can get a bit of a contrast, but really we don't dictate how to do it, each individual teacher does it the way that they think is best.

MLNSFE/135-9

In one case a head of biology at an FE college felt that exposure to the combined specification presented opportunities to provide a more active and individualised student experience, one that he wished to encourage all teachers in his team to use.

T: The new syllabus, I thought, contained a lot of really inspirational topical stuff and I used that as a springboard for all sorts of group work and I translated that into lesson plans for other teachers so that we all adopted that approach, and I really approved of that syllabus.

I: So you were pushing a kind of independent but group work learning approach?

T: Not so much independent, but very much guided, so active learning.

I: OK. Can you give me an example of the sort of thing that you might have been doing then?

T: OK, I will give you one really great example. I suggested that for oxidative phosphorylation we came up with some sort of role play and we had students lined up, three carriers lined up, we had I think it was an apple cut in half and we took two pips out for the electrons. We had an orange at the end, the oxygen waiting to be oxidised and took the hydrogen towards that and we had people with ATP written on their chests being manufactured . . .

CPLNSFE/35-50

Mixing approaches and resources as natural, de facto, practice

Some schools using a mixed approach stated this was because of a commonly adopted, *de facto*, practice that was now their common approach to teaching derived from years of teaching biology at A-level.

When I first started teaching I shared with two colleagues, my head of department and another colleague … who both did their own thing. So one of them taught Nuffield and one taught traditional, it was then the NEAB at the time. I was teaching both classes. So I sort of hybridised

my teaching approach so I didn't have to write two schemes of work. So I am just so used to 'pick and mix' I suppose.

MHS/53-8

In the quote below the teacher, in a non-selective, context-based school, suggested her teaching was a question of mixing from a variety of resources, often home produced, rather than relying on a single textbook.

My style is for me to have my own sort of bank of notes and resources and stuff that I dig out occasionally, so I don't just purely use the text book. I mean in fact I sort of think that, when I teach, I don't tend to refer to the text book until I want them to use it for some reason, do you see what I mean?

CXLNS/85-90

5.2.4 Storylines

In the context-SNAB approach an emphasis is placed on using 'storylines' to embed and relate content. Storylines, such as that used in UNIT 1 to teach the cardiovascular system, link knowledge and understanding necessary to understand and explain aspects of the story, in this case about cardiovascular disease contracted by a 15 year old and a 64 year old. The interviews revealed a range of use of these storylines that tends to reflect the depth of teachers' commitment to the context (SNAB) approach. At one end of the scale are teachers who embrace storylines wholeheartedly, hardly every teaching a topic without using them. At the other extreme are 'storyline deniers' who see this approach restricting more traditional ways in which they believe biology content should be taught. These two quotes represent these extremes.

I: What about the context story lines, did you use those a lot?
T: Yes. I use them all the time.
I: Do you? You don't find a concept-based approach more useful for some topics than others?
T: No
I: You stuck to the context fairly well – the storylines?
T: Yes. Once you have got past the context storyline part of it, you get into the content anyway and I think that was the whole point of doing it like this.

CXLNS/120-8

There's no time to use storylines so no I don't use it … You know, there's no need to … get embroiled in some storyline, you might just as well get stuck in and straight away into the actual biological topic that's of interest, and that's not to say that we don't have storylines, but … I would always give a kind of context to what we are about to study before we start, and that is all the storylines are … I am an advocate, a strong advocate, of trying very hard to avoid prescription as much as possible, so I will not be prescribed to, and that is something that as Head of Department I have cultured my young colleagues to be confident with, and for me a storyline is basically saying this is how you must start this topic. Well I am damned if I am going to be told how I should start a topic. So I don't use them.

MHS/120-131

Between these extremes lie approaches of most teachers interviewed, who see some value in using storylines, but often use them in selective ways. About half of teachers interviewed admitted using storylines more at the start of the course in year 12 (at AS level) than in year 13 (at A2 level).

> *Um, I think it* (the storyline) *works better for AS than it does work for A2 because I think at that stage the girls haven't, ah ... what's the right word? … I think, at that stage, our students still like the story. They hang on to it. I'm not sure it's as effective in A2.*
>
> CXHS/82-9

In the following example a teacher, in a context approach school, tells of his initial reticence but now how he sees the advantages of using a storyline to access biochemical ideas which might have seemed daunting to students if following a more traditional concept-led approach.

> *Well, I think it helps students to sort of keep it real, do you know what I mean? To be honest for me it was quite difficult to adopt that approach to start with. I am a bit sort of old school; you know, learn your stuff and regurgitate it. I know that's bad and is awful, but I found it quite difficult to think, to realise that students can actually learn, probably more effectively, by putting it into real situations. And now I am a real sort of promoter of it. I think it's brilliant. To actually, to make it real, instead of having you know the first few months of pure bio-chemistry which usually just the students think oh, I thought I was doing A level Biology but I am not I am doing pure bio-chemistry, actually they are still learning that bio-chemistry but learning it in a way that actually means something to them. When I ask my students, they love it.*
>
> CXLNS/64-76

In the quote below the teacher, in a non-selective context approach school, seemed to have used storylines more in Y12 (AS) but did not ditch the approach in Y13, preferring instead to supplement a context approach with his own materials:

> *I think certainly to begin with, at AS level, the storylines are very useful, they are very supportive and you can always look back and say this is why this has happened so let's look again at symptoms and so on … and so for that it was very useful. But going into year 13 I think a wider remit is far more valuable. So if we are looking at things like malaria, then it is very easy to find resources from WHO* (World Health Organisation) *and so on, that explains not only the disorder, but gives you a much better picture of how important finding out about it is.*
>
> CXLNS/117-132

In the sequence below the interviewee was a teacher, with over 22 years' experience of A-level teaching, in a selective mixed approach school. Here we can see the influence of being exposed to the storyline approach for the first time and the sense of growing confidence to use this approach more in his teaching as the course proceeded but not in topics where the natural progression and connectivity of concepts was perceived to make learning content more easily accessible for students.

> *I: The orange book, SNAB- Salters Nuffield A-level Biology is very strong on the storyline isn't it … how important do you think the storyline is?*
>
> *T: Well I have now taught the unit one and I have used that book and I have now gone through my Power Points and set it much more in a context and used the same context for*

the cystic fibrosis things as they do in that book, and the kids have been much more motivated.

I: Have they? You have noticed a difference have you?

T: Absolutely.

I: Was that happening during that year?

T: I just came in and I just … well I was finding my feet and trying to . . .

I: It takes time doesn't it to get used to that approach … Now do you think that kind of context-based approach is more suitable for certain topics?

T: I mean I have certainly used it with that first unit with the cystic fibrosis and again with the bit about plant diversity and all of that. In those areas and I have used it in the unit for the infectious diseases and based it around TB and the HIV and the sort of death of someone, those, its worked more but that's maybe because I have spent more time working at it on those topics whereas on some of the other topics, because I have either felt more comfortable that the units link naturally together or you feel you already have nice specific bits that you want to teach as specific bits of content, then I haven't . . .

I: What would those be?

T: So I mean like in the unit five, the brain and the nerves, I mean it sort of flows on naturally because it's all to do with the nervous system anyway, without having to necessarily put it in context.

MLS/82-108

As reported in the last sub-section, storylines tended to be avoided by some teachers where they felt it was more appropriate to get straight to the theoretical side of the biology.

Yes we like the storylines, but then when we go into it sometimes we will just go, "right we are going to teach you about enzymes", and you know have a much more driven lesson on enzymes, so we keep it freer, we allow teachers to make their own minds up but we certainly think the very first two topics are particularly strong for using storylines. We think topic four's story is weak and it is hard enough to engage the pupils in it, so we tend to just get on with the theory. Topic four is the … the brazil nut story … but we find we don't enjoy the story so much and the pupils just want to get the biology done. But we certainly think the cystic fibrosis one is very good, it's always good to come back to the story and the heart as well, it's really good.

MHNS/116-122

5.2.5 Use of ICT

A considerable investment has been made in the last five years in designing and providing ICT and online resources to support teaching of biology at advanced level. Most prominent for the Edexcel examination is the SNAB suite of resources that includes simulations and animations, pupil online support materials, activities and teacher support and assessment materials, all available through online subscription. The concept route has also been supported by electronic support materials replicating activities and resources linked to the green textbooks. Biology teachers today have a vast array of materials on open and registration access web sites such as those provided by universities and publishers such as the TES (Times Educational Supplement). Additionally, schools have seen a growth in use of Virtual Learning Environments (VLEs) that allow bespoke and published materials to be provided on schools' intranets for easy access by teachers and students. Given the amount of ICT support and material available, it was not surprising that every school interviewed gave a number of examples of the use of ICT to support biology teaching. VLEs seem to provide a convenient way to

collate lesson resources in one place and to supplement textbooks. Half the teachers interviewed mentioned the placing of lesson materials including Power Points on such sites. A teacher in a non-selective context school noted:

> *We have a VLE which, you know, any lesson Power Points and things tend to go on, you know, any activities like card sorts, or you know that kind of stuff, yes, the kids will have access to. I mean you can't, there has never ever been a syllabus or a textbook, has there, that actually gives you everything you want.*
>
> CXLNS/112-117

Four teachers mentioned using web resources, often with links for students placed through VLEs, which they felt took advantage of cutting edge bioscience and the large budgets of organisations hosting relevant material. This was one example:

> *I use a lot of university website material, often American, they seem to have huge budgets for this sort of thing … So the University of Utah have super genetics stuff. Um, there's a really good one on the Human Genome Project and on DNA analysis, which has got an interview with the guy who discovered DNA fingerprinting at Leicester, I can't remember his name now. And then it puts it in context with several cases, you know the very first case, of the little lad, and they couldn't prove he was his mother's son …*
>
> CPLNS/112-130

For one teacher, in a low performing non-selective school using the context approach, web-based materials presented an opportunity for students to widen their reading in the subject:

> *Our students are on it* (the internet via the VLE) *and I encourage them to read things like the Bio News that comes up on the online website… All the latest sort of stuff gets put on there for them to keep up to date with the biology… Another secret of success for me is to read around your subject, to read … other things, watch all the programmes on the TV, read all the information that you can get either from journals or books or magazines, but specifically you know using that website to actually . . . I mean they will come in occasionally and say, "did you see that article on the Bio News, I didn't know you could do that, they didn't know they could do that you know. And did you see that they have used STEM cells for . . ." you know, it's all that sort of thing, and I encourage that.*
>
> CXLNS/104-114

Context approach schools were most enthusiastic about using SNAB online materials. It was noticeable that schools involved with SNAB for some time tended to make use of most of the resources and appreciated the flexibility these provided, particularly for students of different abilities and to assess students' baseline knowledge. The following are two examples referring to uses of SNAB online, one from a lower performing state school and one from a higher performing independent school:

> *The students love it* (SNAB online) *and they can access that kind of thing from home and it is all so useful because you can tailor make your lesson to whatever the students needs are, because you don't necessarily have to do the activity in class if you don't need to, you know, sometimes it's a recap and sometimes it's a homework and sometimes it's you know, part of the lesson, it just depends on what the activity is and what the kids can read at the time. Because our classes*

are quite mixed ability, we can't you know, have all of the higher achieving ones in one class because of the options.

CXLNS/99-107

We've always liked the interactive activities that you've got online, I think those are lovely. I'll tell you what we do use frequently is the introductory GCSE preparation. That's a really, really good starting point. Right at the beginning, and I think it gives, well, it's an all-girls school, so we give the girls a really good indicator of where they should be. I think what it also does is it highlights areas that need reinforcement before we even start the A level. So I like those very much, we like the interactive ones.

CXHS/67-77

There were no examples in the interviews of concept schools using SNAB online and just two of the eight mixed approach school said they used it. Both these mixed approach schools expressed frustrations with using the system, associated with speed of access and students' registration. One school believed frustrations of registration were balanced by easier access to good alternative resources elsewhere.

Yes, we like the resources, the animations on SNAB online. The students don't like accessing it themselves. They find it very slow.

MHS/91-4

We used it for the first two years and then we got rid of it. We had massive numbers here so getting them to register on it was a nightmare, to get a hundred students at AS registered, it was horrible, and took up vast quantities of time, and they barely used it, so and we had … our own intranet, online library of exam papers, and with so many good animations on YouTube and other things we just found that students weren't using it, they were using other resources, and put the whole nightmare of doing it, it just wasn't worth the pain of getting everyone on it.

MHNS/155-170

5.2.6 Use of out-of-school learning

As noted from questionnaire returns, most schools interviewed said they valued and used a wide range of out-of-school opportunities for learning at advanced level. All schools but one said they used fieldwork of some kind, often at residential field centres or suitable sites at or near to the school. The most common non-fieldwork visits were to zoos (London Zoo), botanical gardens (Kew) and medical institutes or universities. Often, but not always, visits were used to support UNIT 3 (the visit or issue report). In one case, a mixed approach lower performing comprehensive school claimed that a visit to Kew had a positive impact on students' grades:

We have been to the zoo, we have been to Hampstead but this year we went to Kew and that was a fantastic day we had there, linking into their visitor support… So they had teachers taking them through various plants which are going to be endangered or used for whatever, and then we made that the link. So we didn't stay true to the topic, we said right from this area of your visit do something on conservation on one of the plants that you come across, and there was so much

there, and the grades from them were on average, I would say, a grade higher on that coursework.

MLNS/128-136

As noted in findings from questionnaires, schools make good use of local universities. In the case below, of a non-selective context based school, the university visit also provided advice on examination technique.

We are lucky where we are because Cambridge University isn't far, and quite often there are things like AS Biology conferences where our students are able to go round and look at stuff like that. There is also one that is run at the University of Essex. They do an AS Biology conference where they take the students on a tour of the labs, talk about the work that they … They have an examinations officer there and he does a lecture on exam techniques and how to answer questions, and specific things that they should make sure they know and that sort of stuff. That's quite valuable. So it's not an AS revision session run by the board, it's something that where lots of students from all different schools and all different boards can actually get together and see what's going on.

CXLNS/153-164

Visits to colleges or universities can also provide opportunities for students to engage in activities such as practical work that cannot be done at school:

We went up to the science learning centre (at a local college) *nearby and we went up there and we did some electrophoresis and stuff that we didn't have the equipment for in school.*

MLS/124-6

In another example a university visit served a multitude of purposes, including having contact with working scientists which could have positive benefits as career orientation:

We go to the John Innes Centre with visits and things you know that they put on … I encourage the students to take part in the Nuffield Bursary in the summer holidays and they have been able to get paid employment if you like, or work in research labs either at the John Innes or at the University or at the hospital, because we have got a new hospital up there… They do up to four weeks work with proper scientists and that is absolutely invaluable. I mean, that is just fantastic for them to get into a lab, even if it's not a sort of a subject of particular interest to them, or a field of biology that is of particular interest to them, working in a lab with real scientists is just brilliant.

CXLNS/136-149

The choice of visits can reflect students' interests as well as providing contexts for the UNIT 3 report as in this quote, from a teacher in a higher performing mixed school. Again, a positive impact on results in UNIT 3 was an important outcome.

We encouraged them to do a visit report based on conservation in the very first year. We weren't particularly happy with the marks, because traditionally conservation and ecology type projects, students find difficult to gain marks in because they're not as specific as they should be. The following year we allowed them free reign to do an issue report on anything. And we found the medical based ones got higher marks. We always attend the Manchester medical lectures at

Christmas, so that sort of starts them off with a little bit of the thought processes, trying to think …I can't even think what the 2008 lecture was. But we do that every year. A lot of our students do want to go on to do medicine, and they've already organised work experience visits for themselves.

MHS/166-180

5.2.7 Professional development

In questionnaire returns the contribution of professional development (PD) to student success at A-level was often rated lower than other aspects, such as resource use, practice at examinations and school visits. In the interviews most schools said they had found training provided by the examination board helpful. It should be noted that since the examination in 2010 this type of face-to-face training at meetings for teachers is still possible, especially in relation to teacher assessed components but, under new government regulations, trainers must be careful about the extent of advice they provide on external examinations. More recently extensive online facilities for interaction with examiners have been provided.

Some teachers have experience as examiners and share their expertise with colleagues and sometimes with other schools. In-house PD is quite common and seen to benefit teaching at A-level and in a few cases PD is organised on a cluster basis. This was a comment from the head of a large department in an FE college:

That couple of years (2008-2010), *yes I went to a couple of courses - one on the introduction of the AS and so it was up in London actually, and they did a lot on the issue report, so I went on that. We have all been examiners in the past and one of us is still doing the Unit 2 examiner's job. We are meant to do about thirty hours a year CPD but a lot of it is done in house and is usually about resources really.*

MLNSFE/165-172

In-house or cluster-based PD can sometimes be stimulated by courses held centrally by Edexcel or, in this case, at York by the SNAB team:

I did the SNAB course with Anne, at York. We then set up a whole in-service training session with our staff here.

CXHS/133-4

In one case a selective school had availed itself of the services of an expert in A-level Biology with knowledge of the examination to provide PD, and the comment below summarises some of the advantages of doing this, including ease of access:

When I first came … I made sure that someone went on some training courses and now we have John Dunkerton, who does the unit three coursework come down to the school and they have done something for us…. and he was very good. He came down and we managed to get about ten other local schools to come and do it, because you know we are so far away you don't always want to go up to London. Sometimes these online training courses are not very convenient

because they clash with school meetings or you know, having to go and pick up, you know I have got children to pick up from school after school, so four till six doesn't suit me very well.

MLS/142-153

Another selective school had availed itself of PD opportunities at a local university:

But we also, for our own professional development, we go to any chance we get to go to either the University or John Innes … They put on really good master classes, the teacher science network put on master classes which is purely for us, not for students, and we have been on numerous ones; stem cells, we have been on, oh I can't even remember, you know, we try and go on, we probably do one a year of those because you can't get out of schools very easily.

CXLS/171-181

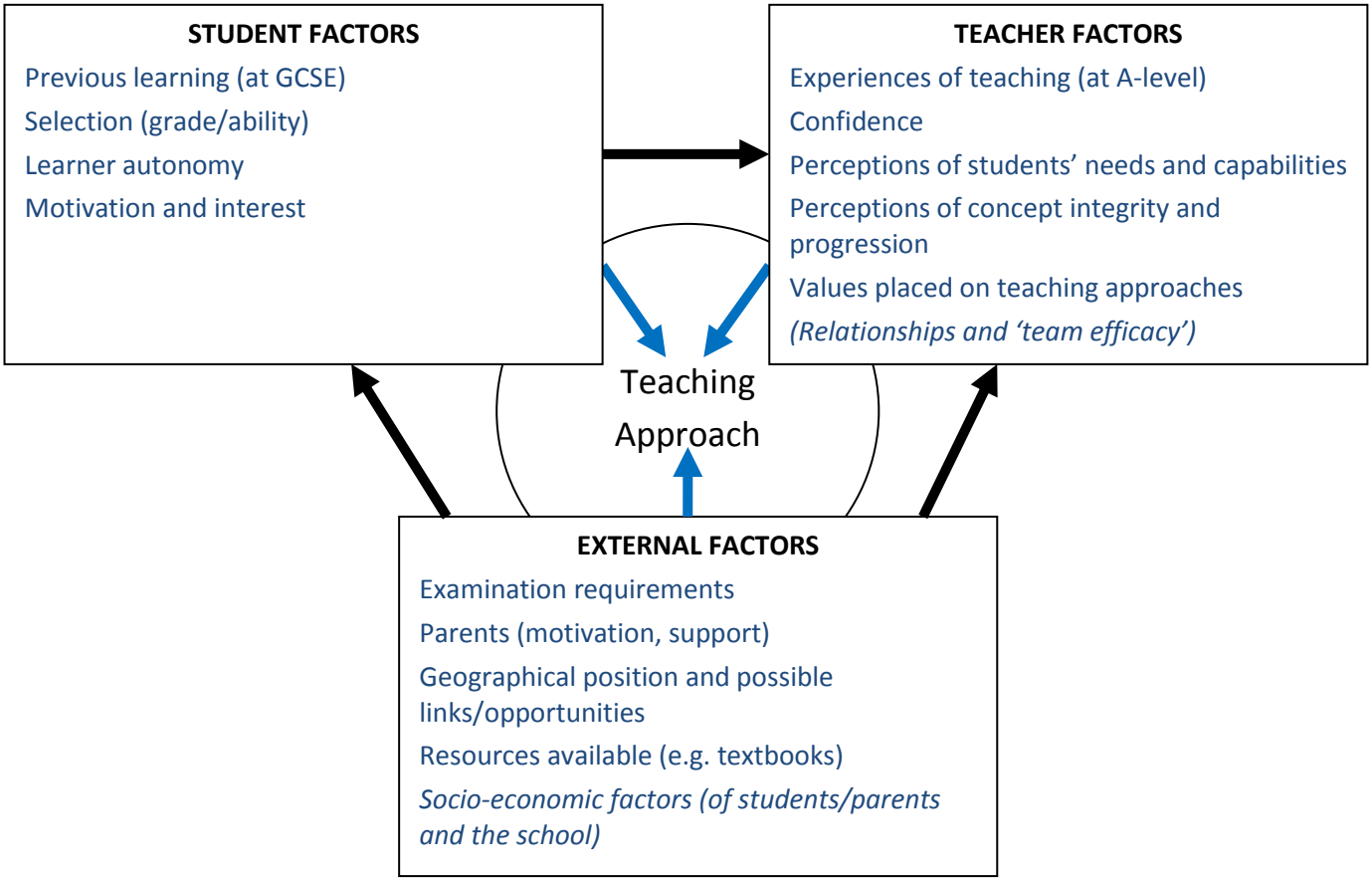
6 Conclusions

Students following a context-based (SNAB-style) approach to studying biology at advanced level do as well in examinations as students following a more traditional concept-led approach. Grade distributions are similar for both approaches for students in all groups of ability based on their previous GCSE scores. In units of the specification in which teachers have some degree of input and control over choice of study, and to a certain degree in assessment, students following a context approach have some advantage over those taught using more traditional approaches. This advantage is slight for the visit/issue report in UNIT 3 but marked for the whole investigation in UNIT 6. Given that assessment objectives for all units of the examination were the same, no matter what approach was taken, there seem to be two interpretations to the findings at UNIT level. First, that SNAB context-led students were more able to perform well in tasks requiring a greater degree of learner autonomy and second, that in these units the task requires setting science within a broad context (especially in UNIT 3, the visit/issue report). Thus in these units the requirement to apply a broad range of knowledge and skills may be closer to intended student outcomes of the SNAB-context approach.

Students following a mixed approach to teaching biology, where their teachers often drew on both context and concept approaches, performed better than students following either mainly context-based or concept-based approaches. The advantages of a mixed approach held for all units of the examination but were slightly less marked in the teacher controlled units (UNITS 3 and 6). These differences due to a mixed approach disappear when the type of school is accounted for. A much higher proportion of mixed approach schools were selective when compared with the other two approaches. It is possible that a mixed approach is part of the advantages already attributable to selective and independent schools. These include greater purchasing power for textbooks by parents and the school and the ability to draw on a wider range of in-school and out-of-school facilities for teaching and professional development. The experience of teaching teams in selective and non-selective schools provided opportunities to apply this experience in making appropriate choices of resources and teaching styles to support students' learning. However, the apparent difference that might be due to school type is not to say teachers choosing to adopt and use a mixture of teaching approaches and resources does not have some advantage for students. Effective deployment of appropriate resources was exemplified by teachers targeting and choosing either concept or context-based teaching where they felt the nature of topics and the integrity and progression of concepts within them was deemed to require one approach rather than another.

Teachers' choices of approach are likely to be determined by three clusters of factors shown in **Figure 6.1**. We see these clusters as being about: *external factors*, *student factors* and *teacher factors*.

Figure 6.1. : Factors impacting teaching approach for A-level Biology



Many of the external factors, and to a certain extent some student factors, are outside the control and influence of teachers but both areas impact teaching approach and resource choice. In **Figure 6.1** the italicised text in two of the boxes show factors that probably have a major impact on teaching approach but that this study did not directly evidence. These are likely to include the socio-economic background to the school that can be manifest, for example, in parental support and financial advantages for student learning and the interpersonal cohesion and effectiveness of teams of teachers. In the independent and selective state schools external factors are likely to have a much more pronounced positive effect, conferring additional advantage in terms of likely student attainment.

In terms of the design of the examination, it may be that the concept-led specification is not ideal in terms of intellectual coherence. Common exam questions could be seen as a compromise between the context-led and content-led approaches. If this is so, how this affects students' attainment was not possible to judge. A more nuanced analysis of performance in different types of questions would be needed, which was outside the scope of this study.

To some extent teachers are reliant on the range and quality of available published resources but there was evidence from this study that they also dip into, use and adapt a wide range of sources including newspapers, YouTube video-clips, online materials, home-produced worksheets and beyond school opportunities for learning biology. For the last of these, beyond school, many of the schools interviewed stressed the importance of opportunities afforded by examples of not only field

work about also chances for students to gain knowledge of real-world applications of biology in research and industry. It should be noted that a recent report by the OECD showed that science-related extracurricular activities at school are related to better student performance, a stronger belief by students in their abilities to handle science-related tasks, and greater enjoyment of learning science even after accounting for the socio-economic background of both students and schools (OECD, 2012).

Student factors impacting teaching approach are likely to include the extent and style of their learning of science-biology at GCSE. However, in responses to the open item of the questionnaire and in the interviews, teachers did not often consider this as an obstacle as they believed most A-level teaching can iron out differences in students' pervious experiences. One or two schools, however, recognised likely impact of the extent to which they could control quality of their intake. Some teachers commented on the firmer commitment of students studying all three, or two, sciences over those following mixed economy A-level courses where biology was combined with non-science subjects. Positive commitment and motivation of students was seen as more likely when students had a biological career, such as medicine, in mind at the start of the course. Again, these student factors are all likely to be particularly positive in the independent and selective state schools.

Teacher factors included experience of the teaching team that breeds confidence in teaching the subject. Confident teachers are able to reassure students that the styles of teaching they use will help them (the students) achieve success. A factor that the study could not evidence but that is likely to be important, is the extent of the cohesiveness of teaching teams and their ability to act as professional communities sharing and reflecting on the suitability and efficacy of teaching approaches and resources.

The choices made by biology teachers, especially about when and how to embed content in a context or to use storylines to lead and develop conceptual understanding, are likely to depend on teachers' beliefs and values attached to using a particular approach and the way they see the arrangement, progression and cohesion of biological knowledge. The study uncovered a range in teachers' commitment to the context-based (SNAB) approach and the student-centred, active learning associated with it. These teacher attitudes did not seem to be linked with whether the school was selective or not. At one end of the scale are teachers who use contexts and storylines to lead the teaching of content in most topics. These are the schools in which the SNAB approach has truly taken root – teachers in these schools are high on a scale of 'SNABiness'. At the other extreme are teachers who do not wish to engage in context-based teaching, believing instead that contexts get in the way of learning content or that the SNAB approach attempts to subvert how they believe biology should be taught by more conventional and traditional methods. The majority of biology teachers lie between these extremes and are 'more' or 'less' 'SNABy'.

The extent of contextualisation, particularly for mixed approach schools, might also depend on teachers' perceptions of what is appropriate for the particular biological concept or process being taught. Maximum contextualisation on the high end of the 'SNABiness' scale entails having a view of biological concepts being encountered and learned across many topics. Concept approach schools may subscribe to what is called a 'traditional hegemony' that maintains a certain way in which knowledge has been traditionally structured. Such hegemony has been identified as a factor influencing ways in which Chemistry may be taught (Van Berkel, de Vos, Verdonk, and Pilot, 2000)

and similar views of biological knowledge may also exist and, hence, affect how it is taught. In a comparison of how context-based chemistry is represented in policy and curriculum documentation, examinations and textbooks in South Africa and the UK, Bennett and Lubben (2008) found a weak version of contextualisation was prevalent, one based on application of taught concepts to contexts (Gilbert's model 1) rather than the context-first approach that is the hallmark of SNAB and other context-led courses (Gilbert's model 2). It may be that teachers new to context-based teaching, and with a traditional (hegemenous) view of topic dependent content, adopt model 1 contextualisation early in their contact with this new approach, and so start low on the scale of 'SNABiness'

Having one specification for Biology, that could be taught by one or the other or a mixture of teaching approaches, has opened up a professional space for teachers' decision making. Teachers that might not otherwise have seen the benefits of teaching using the types of student-centred, interactive activities that SNAB has invested in and developed, have been exposed to ideas new to them. Some of these ideas have been incorporated into their teaching. It may be that the advantageous situations of selective schools may have put them in a better position to capitalise on these new opportunities. The extent to which these changes in teaching approach are ephemeral and may disappear as a result of future changes of A-level specifications remains to be seen.

Where factors in the three boxes in Figure 6.1 are positive, they combine to provide a professional space within which teachers can be creative and innovative. As recognised in the NFER's recent review of studies on effective teaching, expert professional knowledge recognising what teachers do but also their beliefs and values and the evidence on which they base practice are at the heart of effective pedagogy (Rowe, Wilkin and Wilson, 2012). A well-developed professional creative space is one of the key characteristics of successful schools, whatever approach is used, that gives students an advantage in learning biology at A-level.

7 Recommendations

7.1. Recommendations for schools

- Constructing teaching teams, where there is a balance between teachers with some years of experience at teaching biology at A-level and new teachers, helps create a collaborative environment in which a mixture of different resources and teaching approaches can be critically reviewed and selected for their benefits to student learning.

- Drawing on both concept and context-based approaches, and critically evaluating resources within a collaborative and creative professional environment, may positively impact students' performance in A-level biology.

- A 'storyline' approach to teaching biology, where concepts are met through meaningful and contemporary settings, helps students appreciate the interconnectivity of biological ideas and processes and provides sound motivation and engagement for learning at advanced level.

- Using a wide range of out-of-school sources for learning helps students attach meaning to taught biology, to see applications of modern biology, have knowledge of cutting edge advances in the subject and to develop positive orientations towards future careers in biological sciences.

7.2 Recommendations for the Edexcel Examination Board

- Providing a common specification and examination for Advanced Level biology allowed some teachers to meet a range of approaches and resources that might not otherwise have seemed appropriate to support student learning. This supports a mixed approach to biology teaching at this level which is an advantage to students in some schools.

- The promotion and supply of a diverse set of high quality resources including textbooks, revision materials and ICT and online materials supports a diversity of approach which has advantages for student learning.

- Continuing to provide units of the examination that have some degree of teacher input, current units 3 and 6, allows teachers to enjoy some flexibility in their planning and teaching and to draw on a wide range of expertise and out-of-school situations to students' advantage.

- Providing support for teachers' professional development in teaching and assessing biology at advanced level remains an important role of the examination board. Promotion of diversity in teaching approach including the use of student-centred and interactive teaching methods should be part of future programmes.

7.3 Recommendations for teachers' professional development

- Professional development (PD) is important to teachers at advanced level who sometimes feel left out as they see more effort made for teachers of students at earlier stages (KS3 and KS4).

- PD for biology teachers at advanced level should expose participants to as wide a range of teaching methods as is possible. Resources to teach content, both concept-led and context-based, should be experienced by PD participants so that they can judge the advantages of teaching using both approaches.

- Teachers on PD courses in A-level biology teaching should be helped to see ways that concepts and processes in biology interrelate and can be part of more than one topic content area.

- Participants in PD courses should be exposed to case studies of practice of a wide range of examples of out-of-school sources for teaching biology to show how students have attached meaning to taught biology, have seen applications of modern biology, have gained knowledge of cutting edge advances in the subject and have developed positive orientations towards future careers in biological sciences.

ANNEXE A. Overview of units in the Edexcel specification for Biology at Advanced Level.

Each unit may be taught based through either a context approach or a concept approach:

The concept approach begins with a study of the theories and principles of biology and then explores their practical applications.

The context approach begins with the consideration of an application that draws on many different areas of biology. The theories and principles of biology that apply to this application are then studied. This approach is based on the Salters–Nuffield Advanced Biology (SNAB) project.

<table>
<tr><td>AS</td><td colspan="2">Unit 1: Lifestyle, Transport, Genes and Health</td><td>Unit code 6BI01</td></tr>
<tr><td colspan="2">Externally assessed
Availability: January and June (first assessed 2009)</td><td>40% of the total AS marks</td><td>20% of the total GCE marks</td></tr>
<tr><td colspan="2">Topic 1 Lifestyle, health and risk
Context approach presented in the SNAB resources
This topic looks at how lifestyle may affect health, starting with the cardiovascular disease stories of two real individuals, Mark (stroke at 15) and Peter (quadruple bypass at 64). The biological ideas required to understand their story are studied.
Concept approach
This topic begins with a consideration of the structure and functions of a number of molecules, including water, carbohydrates and triglycerides. The structure and function of the cardiovascular system is then considered and the ways in which diet and lifestyle factors may affect the heart and circulatory system. Ideas about correlation, causation and the concept of risks to health are covered.</td><td colspan="2">Content summary
Structure and function of the cardiovascular system
Atherosclerosis and blood clotting role in cardiovascular disease (CVD)
Correlation, causation and the concept of risks to health including determining health risk and perceptions of risk
Factors that increase risk of CVD
Structure and function of carbohydrates, lipids (triglycerides) and water.</td></tr>
<tr><td colspan="2">Topic 2 Genes and health
Context approach presented in the SNAB resources
The context for this topic is a couple trying to decide whether to have a child when there is a chance that it could inherit cystic fibrosis (CF). The topic looks at the questions they may need answered. It examines the symptoms and causes of cystic fibrosis. It includes details of what is happening at a molecular level with protein structure and synthesis. The screening for and treatment of the disease introduces some ethical issues surrounding new techniques.
Concept approach
This topic begins with a consideration of the structure and functions of the cell membrane and gas exchange surfaces. The structure and properties of proteins, enzyme and</td><td colspan="2">Content summary
How CF impairs the functioning of the gas exchange, digestive and reproductive systems.
Structure and properties of the cell membrane and gas exchange surfaces
Passive and active transport
Structure and function of phospholipids and proteins Enzyme action
Structure and role of DNA and RNA
Replication
Protein synthesis (not including mechanism on ribosomes)
Gene mutations</td></tr>
</table>

nucleic acids lead to the genetic code and protein synthesis. Principles of inheritance, gene therapy and genetic screening are included, giving opportunities for discussion of the social and ethical issues surrounding genetic screening for genetic conditions.	Monohybrid inheritance Principles of gene therapy Social and ethical issues related to genetic screening.
Assessment This unit is assessed by means of a written examination paper, which lasts 1 hour 15 minutes.	

Recommended core practicals are identified in each unit. It is expected that all students will have experience of these practicals. Practical-related questions will be asked in the written examination papers and will be based on the knowledge and understanding of the recommended core practicals.

AS	**Unit 2: Development, Plants and the Environment** Unit code 6BI02	
Externally assessed Availability: January and June (first assessed 2009)	**40% of the total AS marks**	**20% of the total GCE marks**
Topic 3 The voice of the genome *Context approach presented in the SNAB resources* This topic considers the most fundamental biological story there is – development from a single egg into a complex multicellular organism. The role of the genome in the control of development is considered. The biological ideas required to understand this story are studied. *Concept approach* This topic begins with an overview of cell structure and considers how cell ultrastructure is related to function. Cell division and cell aggregation to form tissues and organs are also included. The topic then considers meiosis, the formation of gametes, fertilisation, stem cells, gene expression and cell differentiation. The role of the genotype and effect of the environment on phenotype is also stressed.	**Content summary** Cell structure and ultrastructure of eukaryote and prokaryote cells Mitosis and the cell cycle The role of meiosis and fertilisation Stem cells, research and implications Cell specialisation through differential gene expression Genotype and environmental influence on phenotype	
Topic 4 Biodiversity and natural resources *Context approach presented in the SNAB resources* The topic focuses on biodiversity and the wealth of natural resources used by humans. The meaning of biodiversity and how it can be measured is considered first and how all this diversity has come about through adaptation and natural selection. It has sections on both traditional and novel uses of plants and plant fibres and the use of chemical extracts from animals and plants. The concern for disappearing biodiversity and loss of potential natural resources is used to highlight the need for biologists to identify, name and classify species. The topic finishes by looking at the role of zoos and seedbanks in conservation of endangered species.	**Content summary** Biodiversity, adaptations and natural selection Ultrastructure of plant cells Structure and function of polysaccharides (starch and cellulose) Structure and function of vascular bundles in plants Plant nutrition Uses of plant based products and sustainability Drug trials Principles of taxonomy The role of zoos and seedbanks	

Concept approach This topic begins with a comparison of the structure of a typical plant cell with that of an animal cell, and the structure and roles of cellulose and starch. The relationship between plant tissues, xylem and sclerenchyma, is also included. The topic continues with a consideration of the importance of plant products to humans, species diversity, and how diversity arises through natural selection and evolutionary change. The role of zoos in the conservation of endangered species is also described.	
Assessment This unit is assessed by means of a written examination paper, which lasts 1 hour 15 minutes.	

AS Unit 3: Practical Biology and Research Skills Unit code 6BI03		
Internally assessed* Availability: June (first assessed 2009)	**20% of the total AS marks**	**10% of the total GCE marks**
Summary: Students write a report of either a record of a visit to a site of biological interest or a report of research into a biological topic. Students' practical skills will be assessed by the teacher against criteria provided in the specification.		
Assessment: *Teachers have the option of marking the report and having it moderated by Edexcel, or having it externally marked by Edexcel. The work must reflect the standard at Advanced Subsidiary level.		

A2	**Unit 4: The Natural Environment and Species Survival** Unit code 6BI04	
Externally assessed Availability: January and June (first assessed 2010)	**40% of the total AS marks**	**20% of the total GCE marks**
Topic 5: On the wild side *Context approach presented in the SNAB resources* The context for this topic is climate change, in particular global warming. A series of questions are posed - What evidence do we have that climate and ecosystems are changing? What might be causing these changes, and are we partly responsible? The topic addresses these questions by looking at how ecosystems work and the ways in which humans affect them. The topic continues by looking at whether climate change will lead to extinction of species or evolution by natural selection. It considers how knowledge of the carbon cycle can help in maintaining the carbon dioxide balance. *Concept approach* This topic builds an appreciation that photosynthesis is the primary process that underpins the majority of ecosystems, and provides students with an understanding of how ecosystems work. The topic continues by looking at	**Content summary** Ecosystems, habitats, communities, and the factors that affect them Succession Photosynthesis Energy transfer within ecosystems Evidence for global warming The greenhouse effect Using models to predict future changes The effect of climate change on organisms Evolution through natural selection and speciation The carbon cycle and methods of maintaining the carbon dioxide balance	

whether climate change will lead to extinction of species or evolution by natural selection, and looks at the evidence for global warming and its effects on plants and animals. By the end of the topic students should appreciate how scientific understanding can make us aware of our responsibilities as stewards of the environment.	
Topic 6: Infection, immunity and forensics *Context approach presented in the SNAB resources* The context for this topic is the discovery of two bodies. The topic explores how they are identified, and their time of death determined using techniques of forensic pathologists. It considers what caused the deaths; in one case death was due to CVD and in the other infection by pathogens (AIDS and TB). It goes on to determine whether they could have been avoided, studying immunology and treatments including antibiotics. *Concept approach* This topic starts by looking at how forensic pathologists use a wide variety of analytical techniques to determine the identity of a person or other animal, and to establish the time and cause of death of an organism, including humans. It then considers how bacteria and viruses use a variety of routes into their hosts and how hosts have evolved barriers and internal mechanisms to combat infections. These protections are not always successful and many people in the world still die from infectious diseases. This topic also investigates the evolutionary battles that take place between invading pathogens and their hosts.	**Content summary** Forensic techniques for determining time of death The role of microorganisms in nutrient recycling DNA profiling, gel electrophoresis and PCR Structure of bacteria and viruses Infectious diseases (e.g. AIDS and TB) Immunology. Protein synthesis including mechanism on ribosomes and post-transcritptional changes to RNA Barriers to infection Immunity Evolutionary changes to pathogens Antibiotics and hospital acquired infections
Assessment This unit is assessed by means of a written examination paper, which lasts 1 hour 15 minutes.	

A2	**Unit 5: Energy, Exercise and Coordination**	Unit code 6BI05	
Externally assessed Availability: January and June (first assessed January 2010)		**40% of the total AS marks**	**20% of the total GCE marks**
Topic 7 Run for your life *Context approach presented in the SNAB resources* This topic compares how the cheetah manages to run at over 100km/h for a few hundred metres whereas wildebeest and marathon runners can travel many kilometres though not as quickly. It explores the links between an animal's physiology and its performance. The topic summarises the biochemical requirements for respiration and looks at the links between homeostasis, muscle physiology and performance. It ends by looking at how medical technology is enabling more people to participate in sport, and raises the issue as to whether the		**Content summary** The action of the skeletal and muscle system to enable movement ATP, glycolysis, anaerobic/aerobic respiration The control of heart rate, ventilation rate and cardiac output The use of ECG in diagnosis of CVD and other heart conditions Homeostasis Disadvantages of exercising too much or too little.	

use of performance-enhancing substances by athletes can be justified. *Concept approach* This topic begins with a study of muscle structure and function, and the ways in which energy is provided by means of aerobic and anaerobic respiration. The responses of the heart and respiratory system to exercise are included, with the concept of homeostasis and its importance in both the regulation of body temperature and at the molecular level with a reference to gene switching. The topic ends by considering the effects of both too much and too little exercise on the body, how medical technology is used in relation to sports, and the ethical positions with respect to the use of performance-enhancing substances by athletes.	The use of medical technology in sport Performance enhancing including ethical issues How genes can be switched on and off by DNA transcription factors including hormones
Topic 8 Grey matter *Context approach presented in the SNAB resources* The scene is set with a story about Bambuti people who mistook buffalo seen across the plain as insects. It starts by considering how the working of the nervous system enables us to see. Brain imaging and the structure and function of regions of the brain are considered, particularly related to the development of vision and learning. It considers the role of animal models in the study of brain structure and function, and related ethical issues. It investigates how imbalances in brain chemicals may result in conditions such as Parkinson's disease and its treatment with drugs are investigated. Students discuss the ethical issues raised by the Human Genome Project and the risks and benefits of using genetically modified organisms in the development and production of new drugs. Throughout comparisons are made with plants and also the contribution of nature and nurture to development. *Concept approach* This topic begins by considering how plants detect and respond to changes in their environment. This is followed by details of the structure and function of the mammalian nervous system, including imaging techniques to investigate the brain. This is developed into an enquiry into how imbalances in brain chemicals may result in conditions such as Parkinson's disease and its treatment with drugs. The topic requires students to discuss the ethics of the Human Genome Project and to consider the risks and benefits associated with the use of genetically modified organisms.	**Content summary** Coordination on plants and animals The structure and function of the nervous system hormonal coordination How plants detect light using photoreceptors, and the role of IAA in phototropism brain structure and development MRI, fMRI and CT imaging Nature and nurture role in brain development Habituation in animals The role of animal models in investigating brain development and function imbalances in brain chemicals and ill health Human Genome Project. Use of outcomes, and ethical issues this raises Use of genetically modified organisms for drug production and ethical issues this raises

Assessment
This unit is assessed by means of a written examination paper, which lasts 1 hour 30 minutes.

A2	**Unit 6: Practical Biology and Investigative Skills** Unit code 6BI06	
Internally assessed Availability: June (first assessed June 2010)	**20% of the total A2 marks**	**10% of the total GCE marks**
Summary: Students will complete a written report of an experimental investigation, which they have devised and carried out.		
Assessment: Teachers have the option of marking the report or having it externally marked by Edexcel. The work must reflect the standard expected at Advanced GCE level.		

ANNEXE B. Questionnaire issued to the Head of Biology

Please tell us how important you think each of the following was in determining how well A-level biology students in your school performed in the 2010 Edexcel Biology examination. For each statement, please place a tick in **THE ONE** most appropriate box.

		Very important	Important	Not very important	Not important
1	Students' previous attainment in biology				
2	The teaching approach used in Year 11				
3	Experience of the team teaching A-level Biology				
4	Professional development and training in teaching A-level Biology				
5	Professional development and training in teaching and assessment for the Edexcel exams				
6	The school's methods for assessing and monitoring students				

Please tell us about the teaching approach you used to prepare students for the 2010 Edexcel 'A'-level Biology Examination. For each statement, please place a tick in **THE ONE** most appropriate box.

		Strongly agree	agree	disagree	Strongly disagree
7	We often use a storyline to embed teaching of content				
8	We mainly use the Edexcel SNAB (orange) books to help teach content				
9	We mainly use the Edexcel concept (green) books to help teach content				
10	We mainly use a mixture of context-based and concept-led resources				
11	We make good use of lab and equipment resources				
12	We make full use of fieldwork and school visits to teach A-level Biology				
13	Our teachers have plenty of experience of question types used in the 2010 A-level Biology exams				
14	We make good use of ICT and online resources to teach A-level Biology				

Please tell us (in the space below) about any other factors that might have helped your Biology A-level candidates to achieve in the 2010 examination:

Please tell us if you would be willing to be interviewed by one of our researchers: YES/NO (please delete which does NOT apply). If you are willing to be interviewed please tell us your name, school and Email address:

Name: _____School/College_____

E-mail

_____

Thank you for your time.

ANNEXE C. Schedule of questions used in telephone interviews with the selected sample of 16 Heads of Biology.

To start:
Please can you tell me your position-responsibility for teaching (A-level Biology) at the school/college? How long have you been teaching A-level Biology?

What about the other teachers of A-level Biology (for 2008-2010)? How many/who and what was their teaching experience at A-level in 2008?

Basic question:
What was it about the teaching approach in A-level Biology in your school/ college that led to student' successes in the 2010 examination?

Supplementary questions:

Using resources/texts
Can you tell us about the text-book resources you used? What use did you make of texts focussed on context-orange books and the concept-green books? Did pupils have copies of both types of books? When (and for what topics) might you use one or the other approach? Can you tell me why you think xxxx approach might be more suitable for teaching yyyy?

Using ICT
What online and other ICT resources have you used (SNAB online, green book online). How have these helped students achieve in A-level Biology?

Context storylines
How important do you think it is to embed biology content in a story making the learning more relevant (and hopefully) meaningful to students?

Fieldwork – visits
How do you see the place of working outside the school classroom-laboratory for learning Biology at A-level? (probe examples: *Classic ecological fieldwork, visits to botanic gardens/farms/zoos, work at museums, industrial or commercial examples of applied biology, working with or at a university*). If this has had an impact, please say in what ways and how do you know/have evidence of these impacts?

Teachers
Can you tell me about the particular strengths of the teachers in your A-level biology team (that led to success for pupils in the 2010 examination)?

CPD
Can you tell me of any CPD that might have impacted student performance for the 2010 examination?

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